

The ART of *G. R. H.*
DIALLING

Performed
GEOMETRICALLY,

By Scale and Compasses:

ARITHMETICALLY,

By the Canons of Sines and Tangents:

INSTRUMENTALLY,

By a Trigonal Instrument, accommodated with
Lines for that purpose:

T H E

Geometrical Part whereof is performed by *Projecting*
of the *Sphere in Plans*, upon the *Plane* it self, whereby
not onely the *Making*, but the *Reason* also of *Dials* is
discovered.

By WILLIAM LEYBOURN, Philomath.

FK

L O N D O N,

Printed by S. G. and B. G. for Benjamin Tooke and Thomas
Sawbridge next to the Anchor in Duck-lane.

1669

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THE ART OF

DIALLING

2^d Ed.

Performed

GEOMETRICAL

By Scale and Compasses

ARITHMETICALLY

By the Canon of Sines and Tangents

INSTRUMENTALLY

By a Trigonal Instrument
Lined for use



THE

Geometrical Part thereof is performed by the use
of the Sphere in Plane, upon the Principles
not only the Sines, but the Sines and Tangents
discovered.

By WILLIAM LEXBORN, F.R.S.

LONDON

Printed by S. C. and R. C. for Benjamin T. and T. in
St. Dunstons Church Lane in London.

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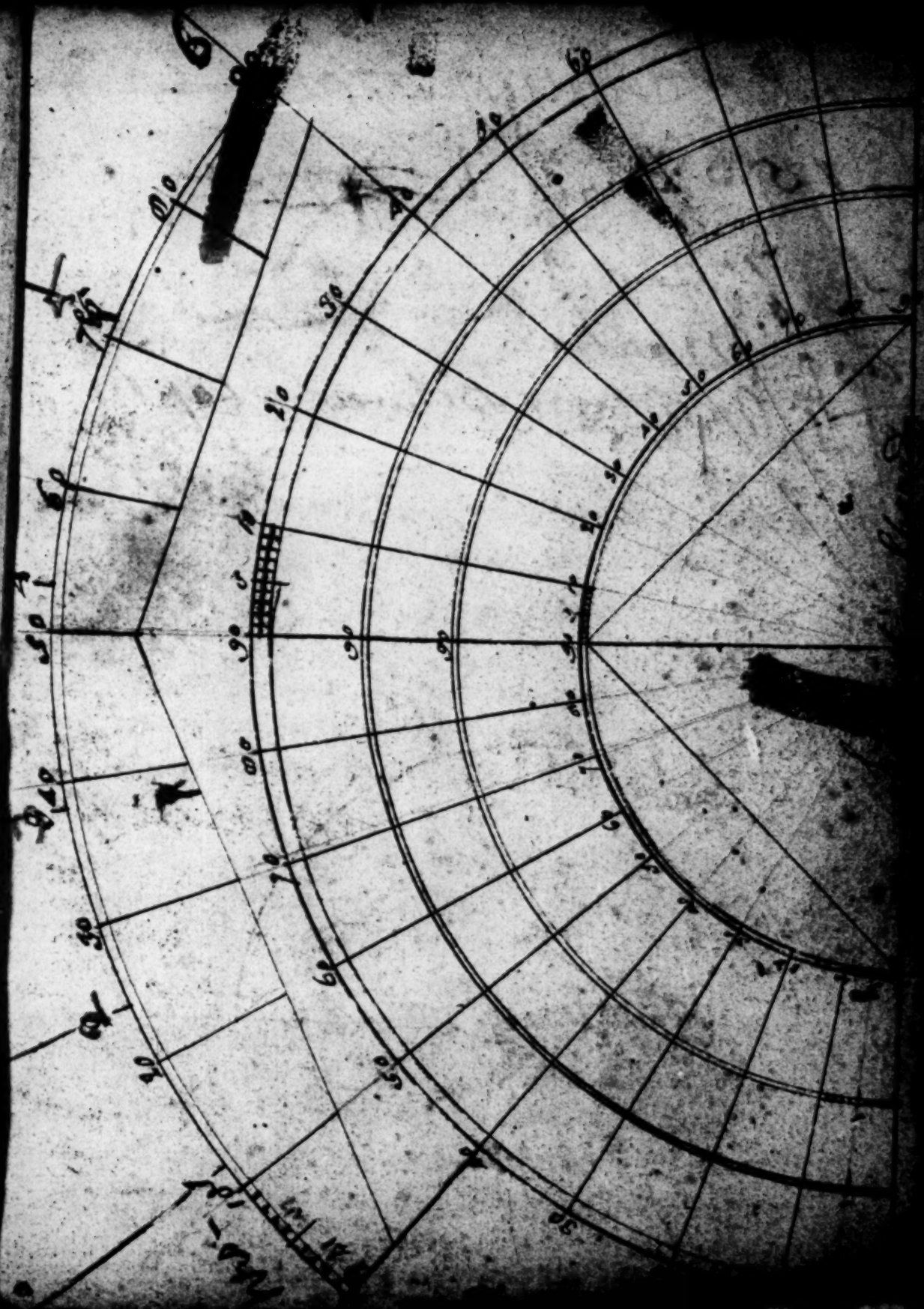
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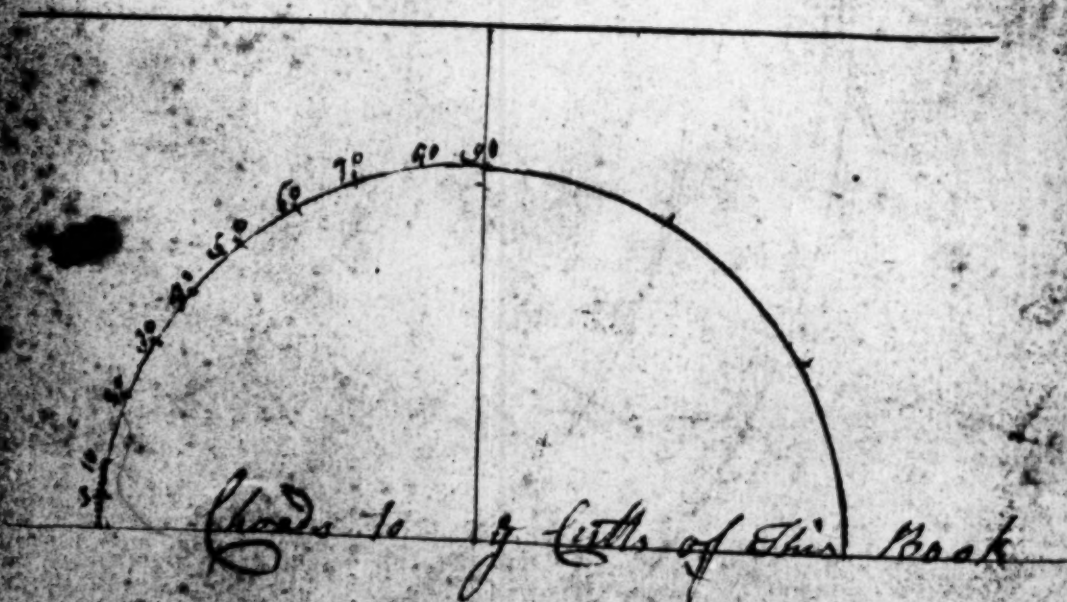
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No 156 Airts ~~1701~~
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also Marked
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TO THE
READER.

THis Treatise of *Dialling* here recommended unto thee, consisteth of three *Parts*.

The first *Part* is Geometrical, and performeth the whole *Doctrine* of *Dialling* by *Scale* and *Compasses*; by *Projecting* of the *Sphere* in *Plano* upon the *Dial Plain* it self, i. e. By drawing upon the *Plain* such *Circles* of the *Sphere* in their true position, as any way relate to the delineating of the *Hour-lines* upon such a *Plain*, let the *Plain* be in any position, and the *Place* in any situation, in respect of *Latitude*; by which manner of delineation, the *hour-lines* being drawn, shall naturally fall in their due places upon the *Plain*, having no other consideration, than only knowing how the *Circles* of the *Sphere* are posited upon the *Globe* it self; which will be sufficient to carry you through the whole *Work*. And to that end (after some few necessary *Geometrical Problems*) at the be-

ginning of the Book, I have some *Astronomical*
Elements giving the Reader a breif account of
those *Circles*, and also of their situation up o
the *Globe*: And in the *Conclusion* of this *first*
Part, I have as my last *Example* of *Declining*
Reclining Dials; which Plains of all others are
the most difficult to draw hour-lines upon) so
Projected the *Sphere* for that purpose, that not
only the *Making*, but the *Reason* also of the *de-*
clination of that *Dial* (and consequently of any
other) is demonstratively discovered.

The *second Part* is *Arithmetical*, shewing how
by *Arithmetical Calculation* (by help of the *Tan-*
gents of *Artificial Sines* and *Tangents*) to find
the situation of any *Plains*, and from thence to
Calculate the true places of the *Stile*, *Substile*, and
Meridian, as also of the *hour distance*, and that
upon all sorts of *Plains*, from the *Horizontal* or
Vertical, to such as *Decline*, or *Recline*, or both.
And in this *Part* I have taken my *Examples* (for
the most part) the same as in that foregoing, and
that for these two *Reasons* principally. (I.) For
the saving my self the labour of *Calculating* of
so many *New* ones. And (II.) but chiefly, for
the *Practitioners* satisfaction, that he may see
what *harmony* there is, between *Arithmetical*
Calcu-

Calculation, and Geometrical Projection.

The third Part is *Instrumental*, and teacheth how to delineate hour lines upon all sorts of *Plains*, by help of a *Plain, Cheap, and Portable Instrument*, which I call *A HOROLOGICAL TRIGON*, by which the *Style, Substyle, and Hour-lines*, upon any *Plain*, may easily and speedily be *Protracted*, having very few lines to draw, but the *Requisites* themselves, and in any case, seldome exceeding the *Confines or Limits* of the *Plain* itself. And with this *Instrument*, and its *Use*, I conclude this *Treatise*.

It may now be expected that I should shew how to *beautify or adorn* those *Dials*, by inscribing upon them other *Spherical Circles and Lines* (besides the common hours) as the *Equinoctial and Tropicks*, the *Parallels of Declination*, *Parallels of the Sun's Place*, of the *Length of the Day*, of the *Sun's rising and Setting*, the *Jewish, Italian, and Babylonish hours*, *Almicatharabs*, *Azimuths*, *Circles of Position*, the *Signs Ascending, Descending, and Culminating*, and the like *Spherical Conclusions*: But in regard that (in part) some years since, I have (in an *Appendix to a Book of Dialling*) published a *Geometrical way of performing many of these Conclusions upon some Plains*.

Plains, I was the more willing to omit them in this place, at this time; my other occasions not giving me so much leasure, as to prosecute those things answerable to my own desire, or the ingenious Practitioners satisfaction. But this I promise (God willing) that in due time (as I find this accepted) I will publish something else of Dialling, and that not only of the making of Dials upon Plains, but upon irregular Superficies also, as upon Cylinders, Cones, and Spheres, both Concarve and Convex, and also upon irregular Concarve or Convex Superficies, and that both by Reflexion and Refraction, with divers other things of the like nature: In the mean time take this in good part, from him who is ready to serve thee in his Employment.

London, Septem-
ber 1. 1669.

Will. Leybourn.

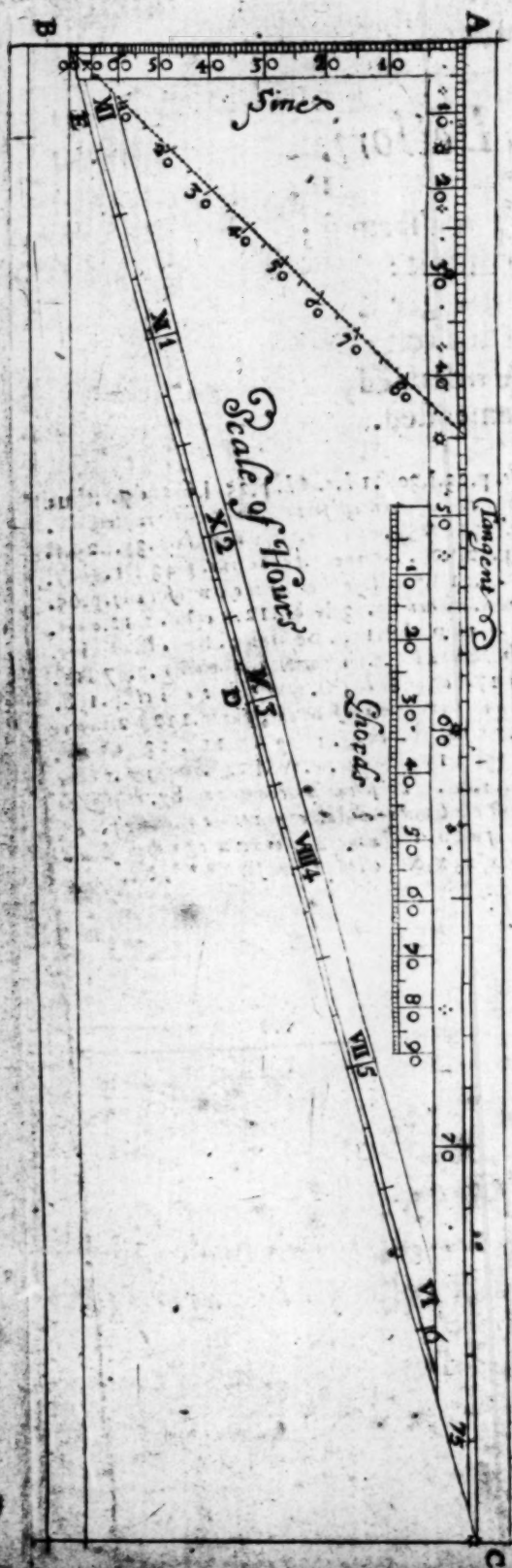
THe knowledge of the Sphere and the Circles thereof being wholly necessary, to be understood for the more ready attaining of the Art of Dialling, I thought good to Advertise, that Globes of all sorts, both Celestial and Terrestrial, made according to the more accurate observations and discoveries, are made and sold by R. Morden, at the Sign of Atlas in New-cheap-side, or in Corn-hill on the West-side of the Royal Exchange. A Treatise of the Uses whereof will shortly be published by me W. L.

Candido Lectori.

Corre^a (Kind Reader) what thou find'st amiss;
 And then it matters not whose Fault it is:
 For all men Err, since Adam first transgressed,
 The Printer Errs; I Err much like the rest:
 The Faults in this, by neither were intended,
 But being past, they thus may be amended.

page 19 line 1 for 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840. 841. 842. 843. 844. 845. 846. 847. 848. 849. 850. 851. 852. 853. 854. 855. 856. 857. 858. 859. 860. 861. 862. 863. 864. 865. 866. 867. 868. 869. 870. 871. 872. 873. 874. 875. 876. 877. 878. 879. 880. 881. 882. 883. 884. 885. 886. 887. 888. 889. 890. 891. 892. 893. 894. 895. 896. 897. 898. 899. 900. 901. 902. 903. 904. 905. 906. 907. 908. 909. 910. 911. 912. 913. 914. 915. 916. 917. 918. 919. 920. 921. 922. 923. 924. 925. 926. 927. 928. 929. 930. 931. 932. 933. 934. 935. 936. 937. 938. 939. 940. 941. 942. 943. 944. 945. 946. 947. 948. 949. 950. 951. 952. 953. 954. 955. 956. 957. 958. 959. 960. 961. 962. 963. 964. 965. 966. 967. 968. 969. 970. 971. 972. 973. 974. 975. 976. 977. 978. 979. 980. 981. 982. 983. 984. 985. 986. 987. 988. 989. 990. 991. 992. 993. 994. 995. 996. 997. 998. 999. 1000.

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THere is now Printed the *Carpenters Rule* made easie.
 By *John Darling*, and is to be sold by *Tho. Santridge*
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WHosoever hath
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 this Instrument, or any
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 in Silver, Brass, or
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 any Latitude at reason-
 able Rates.

Look in page 147



A Connixture of
GEOMETRICAL PROBLEMES.
 AND
ASTRONOMICAL ELEMENTS

PROBL. I.

Upon a right line given to erect a Perpendicular;

DEFINITION.

A Right line is said to be perpendicular to another line, when it maketh the Angles, on either side of the erected line, equal, that is, so that the line inclines not, either to the right or to the left, but standeth upright upon the line, upon which it is erected, as in the following figure the right line A B is said to be perpendicular to the line C D upon which it is erected, because the angles on either side thereof are equal, namely the angle A B C on the one side is equal to the angle A B D, on the other side; and either of these angles are called right angles, and the line A B is called the perpendicular.

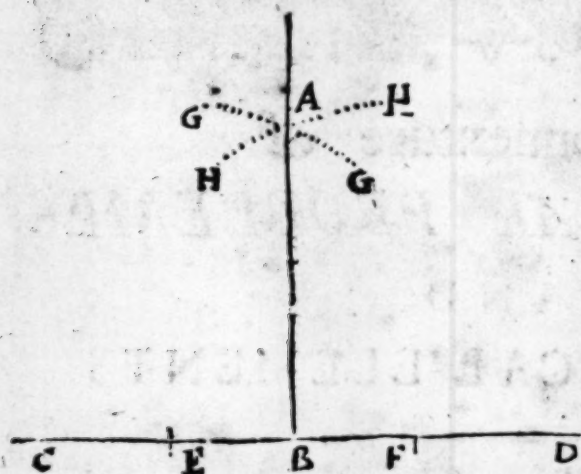
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PRACTICE.

Let CD be a right line given, and let it be required to erect a perpendicular thereupon from the point B , Open your Compasses to any convenient small distance, and set-



ting one foot in the point B , with the other make the two marks E and F on either side of the point B , — This done, open the Compasses to any other convenient distance greater than the former, and setting one foot in the point E , with the other draw

the obscure arch GG , as near as you may guess over the given point B . Again (the Compasses being still opened to the same distance) set one foot in the point F , and with the other foot describe another obscure arch HH , crossing the former in the point A , so is A the point, through which if you draw a right line from the given point B , that right line AB so drawn shall be perpendicular to the given line CD , and from the point B , as was required.

PROBL. II.

Upon (or near) the end of a given right line, how to erect a Perpendicular.

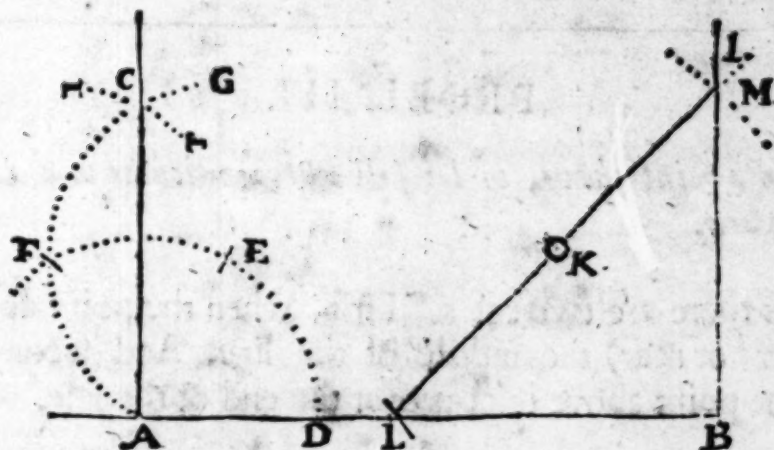
TO effect this, there are several wayes, but I will instance only in two, which are familiar and easie.

The

(3)

The First Way

Let AB be a line given, and from the point A , which is towards the end thereof, let it be required to erect the per-



pendicular AC , — First, open your Compasses to any small distance, and setting one foot in the given point A , with the other describe the Arch FED , then, set one foot of the compasses in D , (they being opened to the same distance) cross the Arch in E , and setting one foot in E , with the other describe the arch AFG , crossing the first arch in F . Again, set one foot in F , and with the other describe the small arch HH , crossing the former in the point C : so the line AC being drawn, it shall be perpendicular to the given line AB , and from the point A , as was required.

The Second way.

Let B be the point given, and from it let it be required to draw the line BI , perpendicular to AB , — Open the compasses to any small distance, and setting one foot in the given point B , pitch down the other foot at all adventures, as at K , so the one foot being in K , turn the other foot about till it cross the given line AB in L , then draw the line KL , and

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and set the same distance KL , (at which the compasses already stand) from K to M , so a line drawn from B , through M , shall be perpendicular to AB , and from the given point B , as was required.

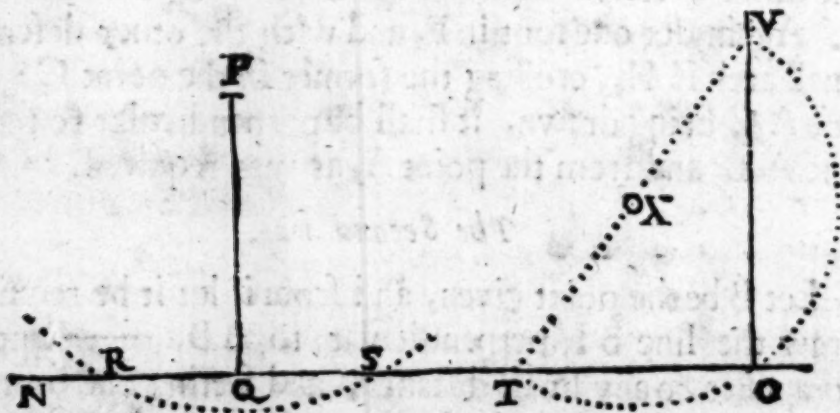
PROBL. III.

How from a point above, to let fall a Perpendicular to a right line given.

IN this there are two cases. First, when the point above is over (or near) the middle of the line. And secondly, When the point above is near over the end of the line.

The First Case.

Let NO be a right line given, and from the point P , over it, let it be required to let fall the perpendicular PQ .
—First open your compasses to any distance greater than



PQ , and setting one foot in the given point P , with the other describe an arch of a circle, cutting the given line NO , in the

the points R and S. Then secondly divide the space between R and S in two equal parts in Q, so a line drawn from the given point P to Q shall be perpendicular to the given line NO.

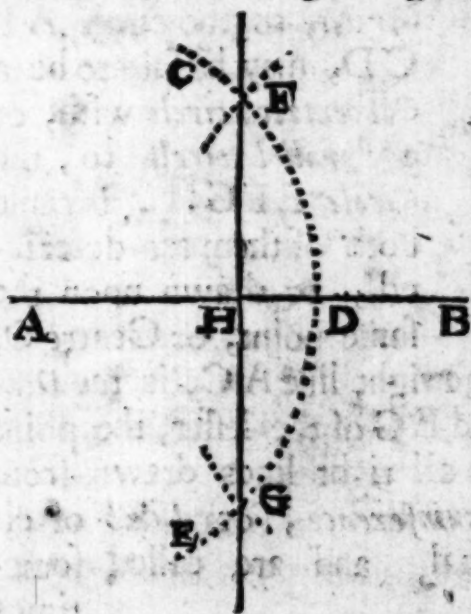
The Second Case.

Let V be the point given, from whence to let fall a perpendicular to the line NO, — First, from any part of the given line NO, as from T, draw a right line to the given point V, which line divide into two equal parts in the point X, with that distance of the Compasses (one foot being placed in X) with the other describe the arch (or Semicircle) VOT, cutting the given line NO in O, so a line drawn from V to O, shall be perpendicular to the given line NO, and towards the end thereof, as was required.

PROBL. IV.

How to divide a right line given, into two equal parts, and at right angles.

Let the line AB be a line given, to be divided into two equal parts at right angles, take in your compasses the length of the line AB, Or (if that be too long) any other distance above half the length thereof, and setting one foot in the end A, with the other draw the arch CDE, then (the compasses unaltered) set one foot in B, and with the other foot cross the former arch (both above and below the line) in the points F and G, Then a line drawn from F to G, shall cut



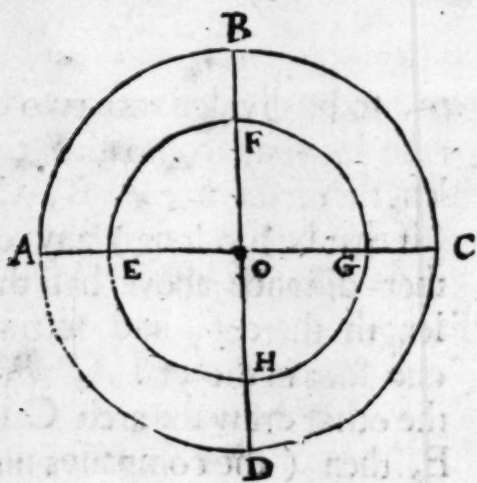
the given line in H, so shall A B be divided, in two equal parts in the point H, and at right angles, which was required.

PROBL. V.

A Right line being given, how to draw another Right line, which shall be parallel therunto at any distance required, or through any point assigned.

DEFINITION.

OF Parallel lines, there are principally two kinds, viz. *Streight or Right lined Parallels*, and *Circular Parallels*. All Circles that are described or drawn upon the same



Centre, whether they be greater or lesser one than the other, are said to be *Parallel* or *Concentrick Circles*, as the circle A B C D, may be said to be a *Concentrick circle* with, or a *Parallel circle* to, the Circle E F G H, because both of them are described, or drawn upon the same point, or Centre O,

And of both these Circles, The right line A C, is the *Diameter* of the greater circle, and E G of the lesser, the point O, is the *Centre* of both, and all right lines drawn from thence to the *Periphery*, *Circumference*, or *Limb* of either of the Circles, are equal, and are called sometimes

times the *Semidiameters*, and sometimes the *Radius* of the circle, as the lines O C or O B of the greater, and O H and O E of the lesser : It containing 60 such degrees or parts, of which the whole circle contains 360.

But *Right lined Parallels*, are such right lines, that being drawn upon the same plain, and infinitely extended on either side would never concur or

B ————— C meet, but always in all parts retain an equal distance, and B ————— D such are the right lines B C and B D in the Margine.

In the describing or drawing the parallel lines there may fall out two Cases or varieties. As,

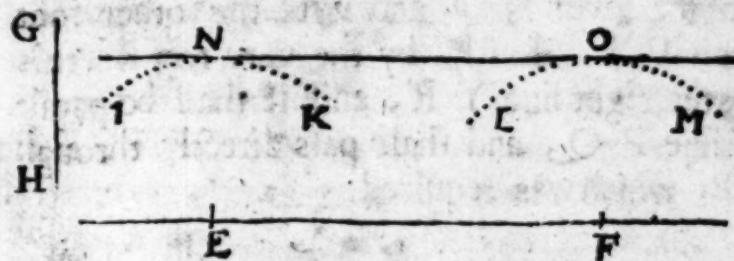
1. It may be required to draw a right line, parallel to another right line, at a distance given. Or,
2. It may be required to draw the Parallel line through a point assigned.

And of this kind there may be two Cases, for,

1. The given point may be over or under the Given line, Or,
2. It may be oblique to the given line.

PRACTICE.
Of the First Case.

Let E F be a right line given, and let it be required to



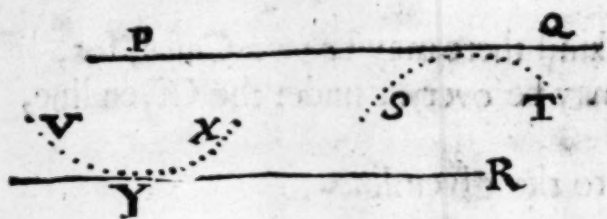
draw another right line parallel thereunto, at the distance of G H.

Take

Take in your compasses the given distance GH , then setting one foot of the compasses in E , (or any other point near the ends of the given line) describe a small obscure arch of a circle IK . Then moving the compasses to F (towards the other end of the given line) describe another obscure arch LM ; then lay a Ruler to the very top of these two arches, so that the Ruler do not crosse, but justly touch, either of them. then by the side of the Ruler draw the line NO , and it shall be Parallel to the given line EF , and at the distance GH , which was required.

The Second Case.

Let PQ be a right line given, and let it be required to draw another right line parallel thereunto, which shall pass through the point R .



First, Set one foot of your Compasses in the given point R , and with the other take the nearest distance to the given

line PQ , which is done by opening or shutting of the Compasses till the moveable point do only touch the given line PQ describing the arch ST . The Compasses still resting at this distance, set one foot in P , (or any other points towards the end of the given line) and with the other foot describe the arch VX . Lastly, by the very top of this arch Y , draw the right line YR , and it shall be parallel to the given line PQ , and shall pass directly through the given point R , which was required.

The Third Case.

Let $A B$ be a Right line given, and let it be required to draw another right line parallel thereunto, which shall pass through the point C .

Take in your Compasses the distance from the given point C , to the end of the given line B ;

At A draw the line B

the line $A B$

the point C

the line $A B$

the point C

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point C , to the end of the given line B ; then set one foot in A , the other end of the given line, and with the

other foot describe the arch $F G$. Again, Take in your Compasses the length of the given line $A B$, and setting one foot of that distance in C , with the other describe the arch $D B$, crossing the former arch in the point H , so the line $H C$ being drawn shall be parallel to the line $A B$, and shall pass through the given point C , as was required.

PROBL. VI. Any three Points, which are not in a straight line, being given; how to find the Centre of a Circle, which shall pass through those three given Points.

Let the three given points be A , B , and C , through which it is required a Circle should be described: First, Set one foot of the Compasses in one of the given points

C

points

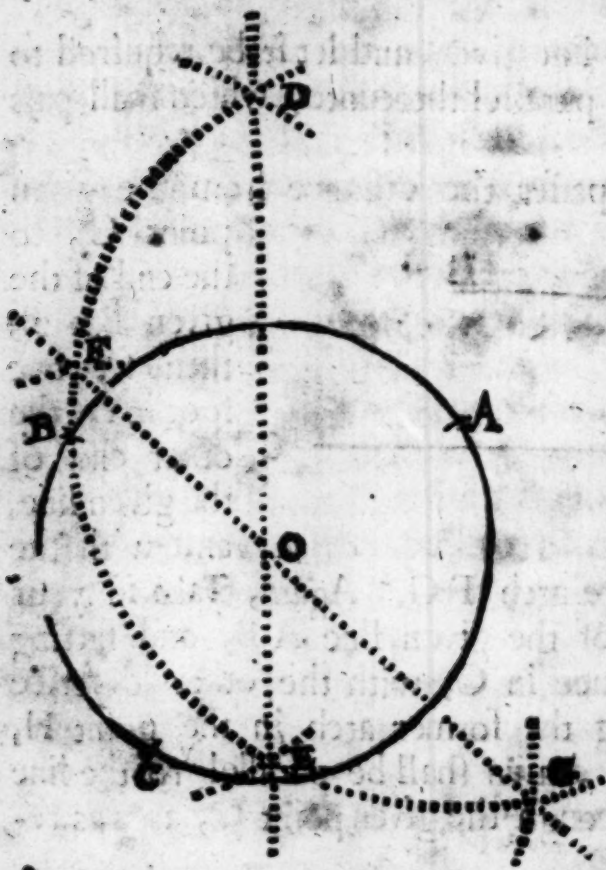
(10)

points A, and extend the other foot to B another of them, and draw the arch of a Circle GFD, — Secondly, the

Compasses not altered, set one foot in B, and with the other cross the former arch with two small arches in the points D and E, and draw the right line DE. — Thirdly,

Set one foot of the Compasses in the third point C, (they still keeping the same distance) and with the other foot cross the first drawn arch, GFD, in the points F and G, and draw the right line FG, crossing the former right line DE, in the

point O, So is O the Centre sought for, upon which if you describe a Circle at the distance OA, it shall pass through all the three given points A, B, and C, as was required.



PROBL

PROBL. VII.

Two Points within a Circle being given, how to find the Centre of a Circle, which being described, shall passe through the two given points; and shall also divide the Periphery, or Circumference, of the given Circle, into two equal Parts.

THis and the foregoing Proposition, come in continual use and practise throughout this work, and therefore ought more especially to be minded.

Let the Circle given be $A B C D$, and the two points within the same, be E and F .



First, through either of the given points (as E ;) draw a right line $E D$ which must pass through the centre of the given Circle at K , —

Secondly, To this line $B D$, draw the line $A C$, through the centre, and at right angles to $B D$, —

Thirdly, From the given point E , draw a right line $E A$, and upon the end thereof A , (by the 2^d Probl.) erect the Perpendicular $A G$, crossing the line $B D$, (it being extended) in the point G , so shall G be

$C 3$

a third

a third point, and then having the three points E F, and G, (by the last Problem,) you may find a centre upon which a Circle being described, shall pass, whose centre will be at H, without the given Circle, upon which point, if you describe the arch of a Circle, at the extent or distance of H E, H F, or H G, it shall pass through the two given points E and F, and shall also divide the given Circle *A B C D*, into two equal parts in the points M and L, which was required, And that this Arch thus drawn doth divide the given Circle into two equal parts is evident, for a line drawn from L to M will pass directly through the centre of the given circle, and shall therefore divide it into two equal parts.

PROBL. VIII.

How to make a Line of Chords Geometrically, to any assigned length or Radius.

FOrasmuch, as through this whole Treatise, there is continual mention and use made of, a *Line of Chords*, it will not be impertinent in this place to discover the making thereof, for the convenience of such, as at all times, and in all places, cannot have the benefit of the Mathematical Instrument-maker, to whom these things are common. Now

DEFINITION.

A Line of Chords is no other than 60 degrees of the Arch of any Circle, transferred from the limb of a Circle to a straight line; Now every Circle, great or small, is divided (or supposed so to be) into 360 equal parts called
Degrees,

Degrees, So the Semicircle contains 180 the Quadrant 90, and the Radius, or Semidiameter (which is that line upon which the Circle or Semicircle is described) noted in the following Figure with the Letters A B is alwayes equal to 60 degrees of that circle which it describes, and therefore 60 degr. of a line of Chords is called the Radius thereof. Thus much for the Definition of a Line of Chords, now for

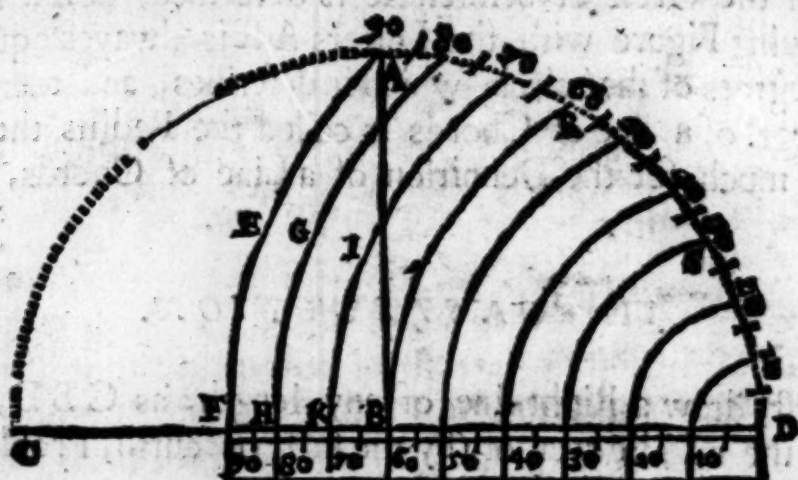
The CONSTRUCTION.

First, draw a Right line of any length, as C B D, and upon the middle thereof (by the first, or fourth, Probleme) erect the Perpendicular A B.

Secondly, Open your Compasses to the Radius or length that you would have your line of Chords to be of, which suppose A B, (which I make here equal to the line of Chords that most of the Schemes and Diagrams in this Book were described by) and with that distance upon B, as a centre, describe the Semicircle C A D, which is divided into two equal parts, or Quadrants, by the perpendicular line A B.

Thirdly, Divide the Arch, or Quadrant, A R D, into 90 equal parts or degrees, which you may do in this manner [Take the length of the line A B, and set it that distance upon the Quadrant A D, from D to R, so is D R 60 deg. and A R 30 deg. Then take the distance A R, and set it from D to S, so is the Quadrant divided into 3 equal parts, at the points S and R, each containing 30 deg. This done, divide the several spaces between A R, R S. and S D, into 3 equal parts, each of which will be 10 deg. according as you see the numbers set to them, these must be again divided into two equal parts, containing 5 degrees, and

and every of thole into 5 smaller as you see in the figure, and so will the whole Quadrant be divided into 90.]



Fourthly, The Quadrant ARSD being thus divided into 90 parts or degrees, set one foot of your Compasses in D, and open the other foot to A, and describe the Arch AEF, touching the line CD in F, so is the point F. upon the right line CD, the Chord of 90 deg.

Fifthly, Open the Compasses from D, to 80 deg. and describe the arch 80 GH. So shall the point H. be the Chord of 80 deg.

Sixthly, Open the Compasses from D to 70, and describe the arch 70 JK, So is K the Chord of 70 deg.

Again, Open the Compasses from D to R, the Radius, or 60 deg. and describe the arch RL B, so is B the Chord of 60 deg. equal to the Radius.

Do the like with 50, 40, 30, 20, and 10 deg. So shall you have the line DF. divided into 90 unequal parts called Chords.

In this manner may you make a line of Chords of any length, and set it upon a Ruler and it is fit for to perform all the uses in this Book, and it were convenient that upon
one

one and the same Ruler you had three, four, or five, Chords of several lengths or Radiuses, as in practice you will find to be necessary and commodious.

Being thus provided of a Line of Chords, I will now shew you how to work Two Conclusions Geometrically, which are of absolute use in Dialling, the one is to find the Hour of the day. And the other is to find the Azimuth of the Sun at any time, and in any place. And with them I shall conclude these Geometrical Problemes, and Astronomical Elements.

ASTRONOMICAL ELEMENTS.

FOR the better understanding of that which followeth, the Reader ought to be acquainted with the Principal Circles of the Sphere. As also, with such other Lines, and Points, as are described and noted upon the Material Sphere or Globe, in imitation of those which are imagined to be in the Heavens. And of so many of these as are necessary for this our present purpose, I shall give you a brief account of. Know therefore, that,

DEFINITION.

A *Sphere* or *Globe*, is a Solid Body, containing only one Superficies, in whose middle there is a Point, from whence all right lines drawn to this Superficies are equal.

The Principal Circles of which a Sphere or Globe is composed are in number 10, whereof Six are great, and Four are smaller Circles.

A *Great Circle*, is that which divideth the Body of the Globe into two equal parts or Hemispheres, and a *Small Circle*

Circle is that which divideth the Globe into two unequal parts.

The Six Great Circles are

- | | | |
|--------------------|-----|-------------------|
| 1 The Horizon, | } { | 4 The Zodiack, |
| 2 The Meridian, | | 5 The two Colmes. |
| 3 The Æquinoctial, | | 6 |

The lesser Circles are

- | | | |
|-----------------------------|-----|-------------------------|
| 1 The Tropick of Cancer, | } { | 3 The Artick Circle, |
| 2 The Tropick of Capricorn, | | 4 The Antartick Circle. |

Of these in the Art of Dialling there is principally but Five to be taken notice of. *Viz.* Three Great Circles, and two smaller Circles.

The Great Circles are,

- 1 The Horizon,
- 2 The Meridian,
- 3 The Æquinoctial.

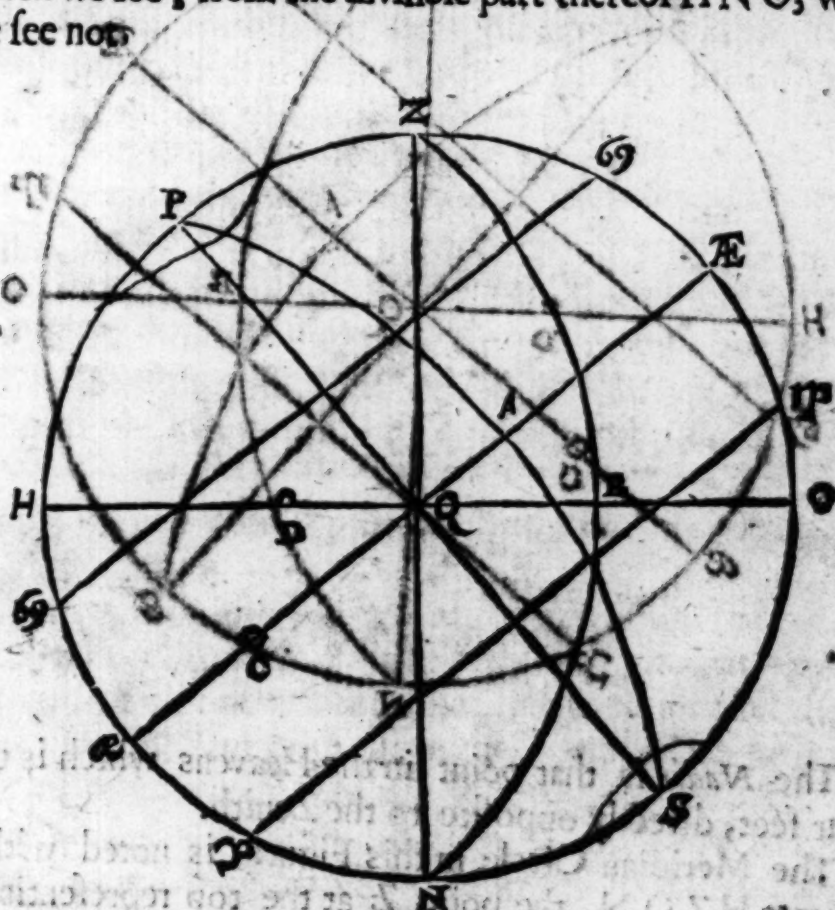
The lesser Circles are

- 1 The Tropick of Cancer.
- 2 The Tropick of Capricorn.

I. Of the HORIZON.

In the following Figure, let the outermost Circle thereof, noted with the Letters H Z O N, represent a Sphere or Globe, then the Horizon is a Circle which divideth or separateth the Visible part of the Heavens which we see, from the invisible part which we see not, and is represented in the

the following Figure by the Line (which represents a great Circle) HQO , separating the Visible Hemisphere HZO , which we see; from the invisible part thereof HNO , which we see not.



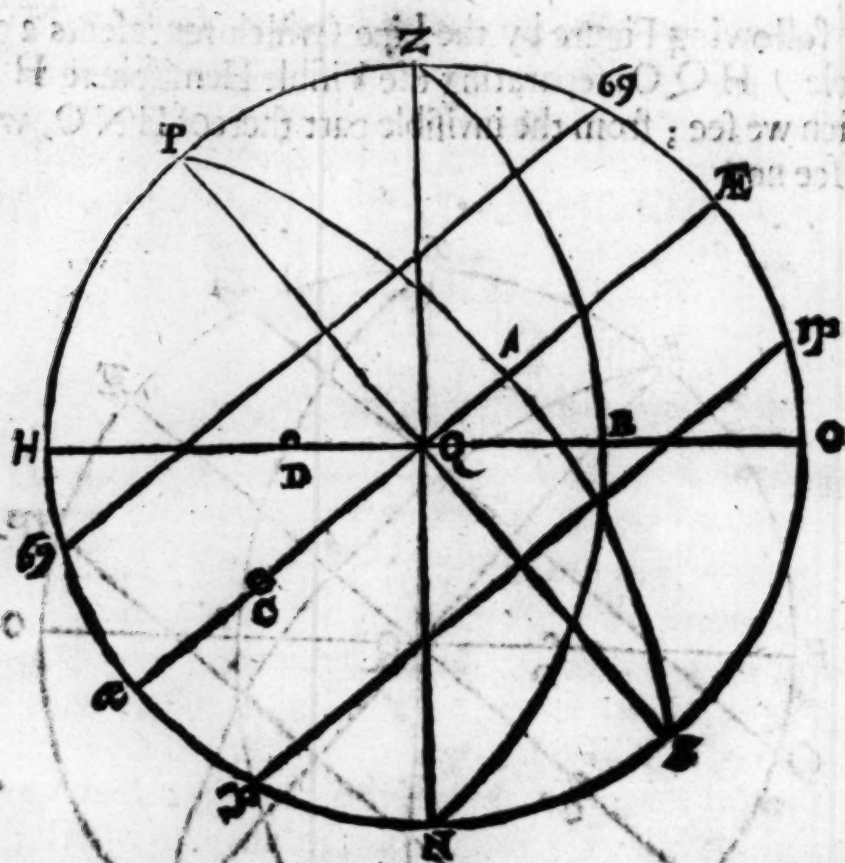
II. Of the Meridian.

The *Meridian* is a Great Circle of the Sphere which passeth by the *Poles* of the World, and through the *Zenith* and *Nadir* of the Place. To this Circle, when the Sun cometh, he being above our Horizon, maketh Noon or Mid-day, and being in the same circle, when it is under the Horizon, it is then Midnight.

The *Zenith* is that point in the Heavens which is directly over your head, in what part of the World soever you be. And,

D

The



The *Nadir* is that point in the Heavens which is under your feet, directly opposite to the Zenith.

The Meridian Circle in this Figure, is noted with the Letters H Z O N, the point Z at the top representing the Zenith, and N the Nadir Points.

III. Of the *Æquinoctial*.

The *Æquinoctial* is a Great Circle of the Sphere, dividing it into the Northern and Southern Hemispheres, which take their names from the two Poles, that being called the Northern Hemisphere, in which the North Pole is seated, and that the Southern in which the South Pole is seated. Unto this Circle when the Sun in his Annual motion

tion arriveth (which is but twice in the whole year) the dayes and nights are of equal length through the whole World.

The Circle cutteth the Axis of the World at Right angles, and is seated in the Heavens 90 deg. or a Quarter of a Circle distant from either of the Poles.

It is represented in the Figure by the Line or Circle Æ Q æ . The two Poles are noted with P and S; P being the north, and S the south Pole; and so the Hemisphere æ P Æ , is the *Northern*, and Æ S æ , the *Southern Hemisphere*. And the Right line P Q S, is the Axis of the World, crossing the *Æquinoctial* at right angles in Q, the Centre, or middle point of the Sphere or Globe.

IV. Of the ~~Two~~ Tropicks.

The two Tropicks are smaller Circles of the Sphere described parallel to the *Æquinoctial* Circle, and at 23 deg. and a half distant therefrom, that being the greatest declination that the Sun hath from the *Æquinoctial* towards either of the Poles. Of these Circles one is called the *Tropick of Cancer* or Northern Tropick, the other The *Tropick of Capricorn*, or Southern Tropick, so denominated, from the Poles which they respect or behold. As the Tropick of Cancer, marked with the character of Cancer ☊ ☋ at each end thereof, beholdeth P, the North Pole, and the Tropick of Capricorn, noted with the Characters of *Capricorn*, ♊ ♋, at each end thereof respecteth S, the south Pole.

These two Circles are the bounds or limits of the Sun's course, for between them he alwayes moveth, never going more northward or southward, 'that is declines not nearer to any of the Poles) than 23 deg. 31 min. Wherefore, when the Sun in his annual course, shall arrive to the Tro-

pick of *Cancer*, which is about the 10th or 11th of *June*, he maketh the longest dayes to all that inhabit in the Northern Hemisphere. And when he arriveth to the Tropick of *Capricorn*, which is about the 1th of *December*, he maketh the shortest dayes to those that inhabit the Northern, and the longest to those of the Southern Hemisphere.

Besides these Circles here named, there are divers others described upon the Globe, Two sorts whereof are of great use in Dialling, and therefore I shall make them known, viz.

Hour Circles, and Azimuths.

Hour Circles are great Circles of the Sphere, which meet together in the Poles of the World, and cross the *Æquinoctial* at Right Angles; of which, the Meridian (or outward Circle in this figure) is the hour Circle of 12, the streight line P Q S, which represents the Axes of the World, is also the Hour-circle of Six, and all the rest of the hour circles are drawn from Pole to Pole between them, as the Circle P A S, represents the hour circle of 8 and 4 a clock, and so of all the rest, which are 12 in Number, representing the 24 hours of the day and night being taken round the Globe or Sphere.

Azimuths are also Great Circles of the Sphere, meeting together in the *Zenith* and *Nadir* points, and fall upon, or intersect, the Horizon, at right angles; as the Hour-circles do the *Æquinoctial*. Of these Circles, the outermost Circle of this figure, represents the North and South Azimuth; and the line Z Q N the Azimuth of East and West; and is commonly called the *Prime-Vertical Circle*. And all other

other Circles drawn through the Zenith and Nadir points, and cutting the Horizon at right Angles, are intermediate Azimuths, between the East and West, and the North or South points. As in the Figure, the circle ZBN is an intermediate Azimuth between the South and the West, it being 40 deg. distant from O the South point.

Every Circle of the Sphere hath its proper Poles, which are alwayes 90 deg. distant from it in all parts.

So in the former Figure Z the Zenith, and N the Nadir points, are the Poles of the Horizon, they being 90 deg. distant from O the South point, from Q the West point, and from H the North point of the Horizon.

Also Q is the Pole of the Meridian Circle HZON, it being 90 deg. distant therefrom in all parts.

Again P and S, the North and South Poles of the World, are also the Poles of the Equinoctial Circle, they being removed therefrom on either side 90 deg.

But the Pole of the Hour-circle PAS is at C, and the Pole of the Azimuth Circle ZBN is at D, and how to finde these Poles, and also the Poles of any oblique Circles, shall be discovered in divers places of the following discourse, where there is often occasion for the finding of them.

Note, And whereas throughout this Book there is continual mention made of Degrees and Minutes, know, that a Degree is the 360 part of any Circle, each of which degrees is supposed to be divided into 60 parts called Minutes, so that 45 min. is three quarters of a degree, 30 min. half a degree, and 15 min. one quarter of a degree, &c.

These are such *Astronomical Elements*, as I conceive, most necessary for the understanding of that which follows,
it

it resteth now that I shew how to perform two or three *Astronomical Conclusions*, Geometrically, without which the knowledge of making of a Dyall will be of little validity; For to what purpose will a Diall serve, without it be rightly placed? Or, how can you make a Diall for any appointed place, without you first know the position or situation thereof? and to these purposes are the following Conclusions subservient.

And because it is requisite to know at all times of the year, what declination the Sun hath from the Equinoctial either Northward or Southward, I have therefore at the end of this Introduction, inserted two Tables, the one shewing the Suns declination every day in the year. And the other a Table shewing the Latitudes of all the Principal Cities and Towns in England, Scotland and Ireland.

PROBL. IX.

Having the Latitude of the Place, the Altitude of the Sun, and the Day of the Moneth given, to finde the Hour of the Day, and Azimuth of the Sun.

Let the Place be *London*, whose Latitude is 51 deg. 32 min. — Let the Suns Altitude be 45 deg. — And let the day of the Moneth be the 11th of *May*, at which time, [by the following Table of the Suns Declination is 20 deg. 20 min. North.

First, Describe the Circle *H Z O N*, representing the Meridian of the Place; — Cross it at right angles with the two diameters *H Q O*, for the Horizon, and *Z Q N* for the Prime Vertical Circle, or Azimuth of East and West. Secondly,

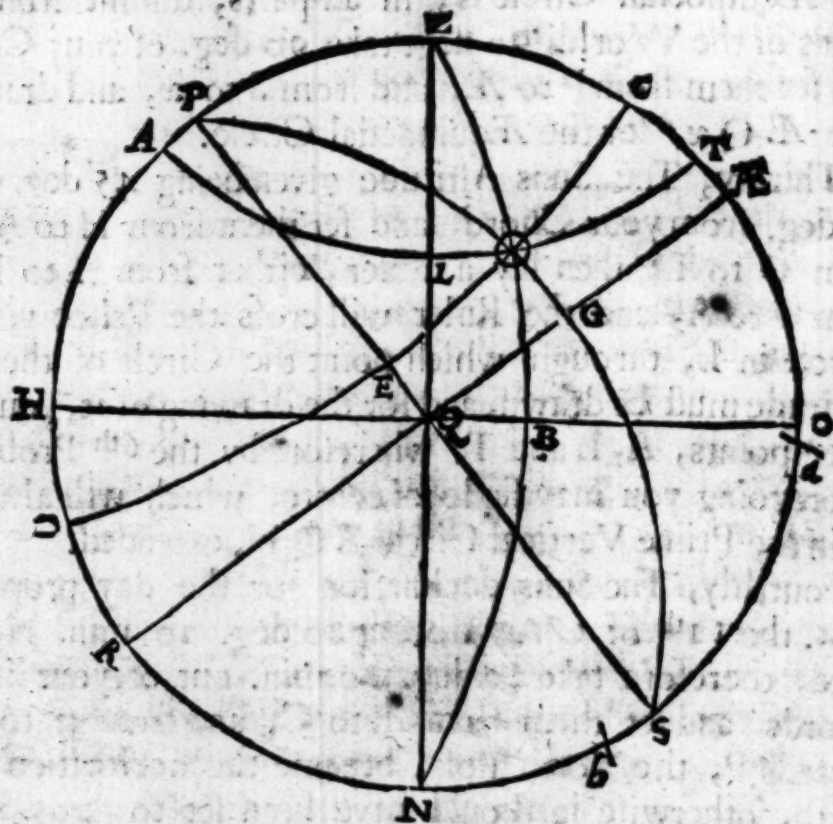
Secondly, Take 51 deg. 32 min. the Latitude of the Place, out of your Line of Chords, and set it from H to P the North; and from O to S, the South Pole; and draw the line P Q S, for the Axis of the World. And, because the *Æquinoctial Circle* is, in all parts, distant from the Poles of the World, 90 deg. take 90 deg. of your Chord, and set them from P to *Æ*, and from S to *æ*, and draw the line *Æ Q æ*, for the *Æquinoctial Circle*.

Thirdly, The Suns Altitude given being 45 deg. Take 45 deg. from your Chord, and set them from H to A, and from O to T; then lay a Ruler, either from H to T, or from O to A, and the Ruler will cross the Prime vertical Circle in L, through which point the Circle of the Suns Altitude must be drawn, and for the drawing of it, you have three points, A, L and T. wherefore by the 6th Probleme beforegoing you may finde its centre, which will alwayes be in the Prime Vertical Circle Z Q N, extended.

Fourthly, The Suns declination for the day proposed, (*viz.* the 11th of *May*.) being 20 deg. 20 min. Northward, therefore take 20 deg. 20 min. out of your line of Chords. and set them from *Æ* to C, and from *æ* to D, towards P, the North Pole, because the declination was North, otherwise it should have been set towards S the south Pole.—— Then laying a Ruler either from *Æ* to D, or from *æ* to C, it will, in both cases, cut the Axis of the World in E, through which point the Parallel of the Suns declination for that day must be described; and for the drawing of it, you have three points D E C, whose centre will alwayes be in the Axis of the World S Q P, extended, and may be found by the former 6th Probleme.

Fifthly, Observe in your Scheme, where the Parallel of Altitude A L T, and the Parallel of Declination D E C,
do

do cross each other, which you will see to be at the point \odot , and that is the place of the Sun at the time of the Question.



Sixthly, By the forementioned 6th Probl. draw an Hour circle through the three points P, \odot and S. whose centre will alwayes be in the Æquinoctial line extended, if need be, also, through the points Z \odot , N, draw an Azimuth Circle, whose centre will alwayes be in the Horizon extended when need requires.

These two Circles being thus drawn, your Scheme is prepared for the finding both of the Hour and Azimuth in this manner.

I. For the HOUR.

Lay a Ruler to P, the Pole of the World, and G, the point where the Hour-circle crosseth the *Æquinoctial*, and the Ruler will cut the Circle in *a* So the distance from *a* to *E* being measured upon the line of Chords, will be 48 min. which is the hour of the day, counted from noon, found to contain 41 deg. which reduced into Time (by allowing 15 deg. to an hour, and 4 deg. to one minute of time) will be two hours, 47 minutes, that is either 47 minutes after 2 in the After-noon, or 13 minutes after 9 in the Forenoon.

II. For the AZIMUTH.

Lay a Ruler to Z the Zenith, and to B, the point where the Azimuth Circle crosseth the Horizon, and the Ruler will cut the Meridian Circle in the point *B*, so the distance BQ, being measured upon the line of Chords, will be found to contain 62 deg. 8 minutes. And such is the Sun's Azimuth from the South part of the Meridian. Of the distance NB, being measured upon the Chords, will be found to contain 27 deg. 32 min. which is the Sun's distance or Azimuth from either East or West, according to the time of the day.

Thus by one and the same Projection of the Sphere, you have found both the Hour and the Azimuth, and many other Conclusions Astronomical might be wrought by this way of Projection, which I have more fully shewed in my *Geometrical Exercises*, now lately published. But seeing that the Azimuth is of such frequent use in Dialling that nothing can be

done, to purpose, without it, and that in this way of Projection sometimes the centres of the Circles will be very remote, I will here shew you another Geometrical Way whereby you may finde the Azimuth at any time, and in any place by straight lines, which will be some light and ease to the Practitioner, that so he may compare one Way with the other, in case of any doubt, which will be a good confirmation of his Work.

Another way to find the Azimuth.

I Et the given latitude be 51 deg. 32 min.

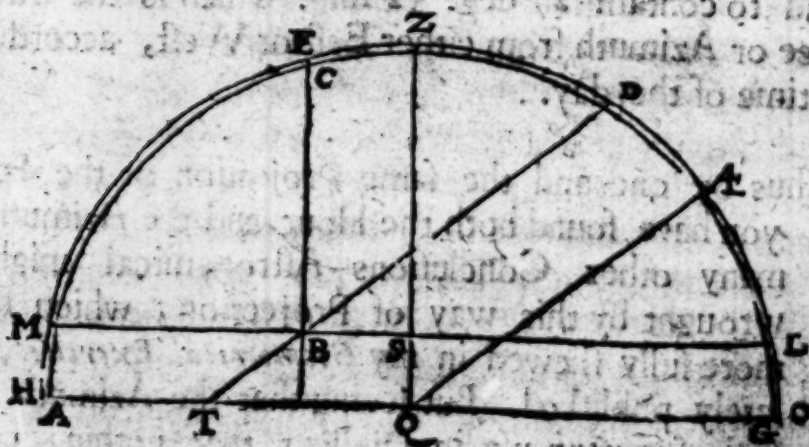
The declination North, 20 deg.

The Suns Altitude 12 deg.

And let the Suns Azimuth be required.

First, Upon the centre Q, describe the Semi-circle H Z O for half the Meridian, and upon Q, raise the Perpendicular Q Z, so is Z the Zenith.

Secondly, Set (by help of your Line of Chords) 53 deg. 32 min. the Latitude of the place, from Z to E, and draw EQ for the Equinoctial.



Thirdly, Set 20 deg. the Suns declination, from Æ to Z (being it is North) and draw the line D T parallel to Æ Q , so is D B T the Parallel of the Suns declination.

Fourthly, Set 11 deg. the Suns Altitude given from O to L , and from H to M , and draw the line M L , for the Parallel of Altitude.

Fifthly, Take in your Compasses, half the length of the Parallel of Altitude S L or S M , and with that distance, upon Q , describe the Semi-circle A C G .

Sixthly, From the point B , which is, where the Parallel of declination, and the parallel of Altitude, do intersect, erect the Perpendicular B C , till it touch the innermost Semi-circle.

Lastly, Lay a Ruler from Q to C , and it will cut the outermost Circle in E , so shall H E measured upon the line of Chords, be 72 deg. 52 min. the Suns Azimuth from the North part of the Meridian,

E Z shall be 17 deg. 8 min. the Azimuth from East or West. And,

E O shall be 107 deg. 8 min. the Azimuth from the South part of the Meridian.

Having thus made this fair preparatōve, I will now come to the Art of Dialling, the thing chiefly in this place intended.

Now the Art of Dialling consisteth chiefly in the finding out of the true distance each hour of the day, and the way to continually vary, according as the style upon which they are described, or projected, are

THE

The ART of
DIALLING
 GEOMETRICALLY
 Performed ,

By projecting of the Circles of the SPHERE
 upon the Plain it self:

CHAP. I.

Of the several sorts of Plains upon which Dials are usually made.

A Dial may be made upon any plain Superficies, and all plain Superficies are posited in one of other of these three positions, *viz.* either *Parallel*, *Perpendicular*, or *Oblique* to the *Horizon* of the Place, wherein the Plain is seated, and all the home-lines drawn upon any Plain, are great Circles of the Sphere, which being projected upon a plain Superficies, become strait lines.

Now the Art of Dialling consisteth chiefly in the finding out of these lines, and their true distances each from other, the which do continually vary, according as the Plains upon which they are described, or projected, are sci-

scituated in respect of the HORIZON of the Place.

Of these
Plains there
are but 3
Varieties,
viz.

1. *Parallel* to the Horizon, as is the *Horizontal*
(which I call vertical) Plain only.

2. *Perpendicular* to the Horizon and such are all erect Plains.
which be either Direct as North and South. East and West.
Or Declining.

3. *Reclining* from the Zenith, or inclining to the Horizon. and these are either Direct } Reclining & inclining North and South, or East and West
Declining } Or Reclining and Inclining

Now in the making of particular Dials, which are in number 25, which I reduce to 17 by supplying the inclining Plains from their opposite recliners, which are indeed the same.

And to avoid mistakes, which may possibly arise by comparing my examples with other Authors; or others with mine. You are to take notice, that I denominate all my Plains from the sight (or the Positions) of their Axis in the Heavens, and not from the Circles of the Sphere in which they lie. Therefore

The Art of Dialling.

These Plains	Horizontal	Vertical.
which most	Vertical	South and North direct.
Writers call	Meridian	East and West direct.
	Equinoctial	Polar.
	Polar	Equinoctial.

And so of all the rest,

And for this Reason.

Because the Pole of the	Vertical	Plain lie in the	Vertex or Zenith of the Polar.
	South and North direct		South and N. parts of the Horizon.
	East and West direct		E. & West points of the Horizon.
	Polar		Pole of the World
	Equinoctial.		Equinoctial.

Again,

All leaning Plains whether direct or declining, whose upper faces behold the Zenith, I call *Recliners*, and the other, or under, faces of them, which respect, or look down to, the Nadir, I call *Incliners*.

This distinction being made, the Plains, of all which Examples following, are thus denominated.

1. Vertical or Horizontal.
2. South and North direct.

3. East

3. East and West direct.

4. South and North, declining } East
Or,
West

5. East and West direct } Reclining,
Or,
Inclining.

6. Equinoctial, Or South Reclining or Inclining, to the Pole.

7. } South direct reclining or Inclining } lesse } than the
8. } } } more } Pole.

9. Polar, Or North Reclining or Inclining to the Equinoctial.

10. } North direct Reclining or Inclining } lesse } than the E-
11. } ing } more } quinoctial.

12. Equinoctial, Or South declining East or West Reclining or Inclining to the Pole.

13. } South declining East or West Re- } above } the Pole
14. } clining or inclining } under }

15. Polar or North declining East or West, Reclining or inclining to the Meridian and Equator.

16. } North declining East or West } above } the intersection
17. } Reclining or Inclining } under } of the Meridian
and Equator.

Thus are the several Plains denominated, I shall now shew how the situation of any Plain may be attained, either in respect of its declination or Reclination.

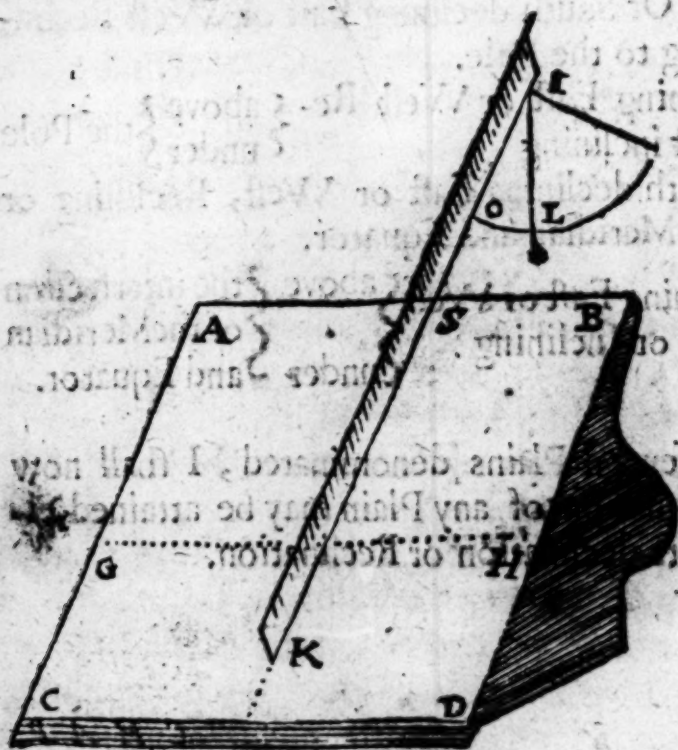
C H A P. II.

How to find the Reclination and Declination of any Plain.

I. *For the Reclination.*

THe Reclination of a Plain, is the Arch of that Vertical Circle or Azimuth, which is perpendicular to the Reclining Plain, or that Azimuth, in which the Pole of the Reclining plain lieth, comprehended between the Zenith of the place, and the Reclining plain.

To find which, Let $A B C D$ be a Reclining plain, draw first thereon by help of a Ruler and Quadrant, a line $G H$ parallel to the Horizon of the place, which shall be the Horizontal line of the Plain, and cross it at right angles with another right line $K S$, for the Vertical line of the plain, to this Vertical line $K S$, apply a straight Ruler $K I$, and to that



that end of it, which lieth clear of the Plain as I, apply a Quadrant as O, L, I, having a thread and plummet hanging from the centre at I, then see what number of degrees of the Quadrant are contained between O and L, for so much doth the Plain Recline from the Zenith.

II. For the Declination.

The declination of a Plain is an arch of the Horizon comprehended between the Pole of the Plain, and the Meridian of the Place, or it is the distance of the Plain it self, from the prime Vertical Circle, or Azimuth of East and West.

To find out the declination of any plain, there are required two observations, the first of the Horizontal distance of the Sun from the Pole of the Plain, and Secondly of the Suns altitude taken at the same moment of time.

1. To find the Suns Horizontal distance from the Pole of the Plain, apply one edge of a Quadrant to the Horizontal line of your plain, so that the other may be perpendicular to it, and the Limb of the Quadrant may be towards the Sun, and hold the whole Quadrant Horizontal (as near as you can conjecture). Then holding up a thread and plummet at full liberty, so that the shadow of the thread may passe both through the Centre and Limb of the Quadrant, observe then the degrees cut by the shadow of the thread, and number them from that side of the Quadrant that standeth square or perpendicular to the Plain, For those degrees are the Horizontal distance required.

2. This Horizontal distance and the Suns altitude being
F
observed

observed at the same time will help you to the Plains declination by the rules following.

First, by having the altitude you may find the Azimuth by the two last Problems of the Introduction, Then by comparing the Azimuth, and this distance together, you may find the plains declination in this manner.

When you make your observations of the Suns Horizontal distance, mark whether the shadow of the thread fall between the South, and that side of the Quadrant which is perpendicular to the plain.

1. If the shadow fall between them, the Azimuth and distance added together do make the declination of the plain, and in this case the declination is upon the same coast whereon the Suns Azimuth is.

2. If the shadow fall not between them, then the difference between the distance and Azimuth is the Plains declination, and if the Azimuth be the greater of the two, then the Plain declines to the same Coast whereon the Sun is; but if the distance be the greater, then the Plain declines to the contrary coast.

And here note, that the declination thus found is always accounted from the South, and that all declinations are counted from either South or North, towards either East or West, and must never exceed 90. degrees.

1. If therefore the degrees of declination do exceed 90. you must take the residue of that number to 180. and that shall be the Plains declination from the North.

2. If the degrees of declination exceed 180. degrees then the excess above 180. degn. gives the Plains declination from the North, towards that Coast, which is contrary to the coast whereon the Sun is.

I. Of the Vertical Plain.

C H A P. III.

How to draw the Hour-lines upon a Vertical (commonly called Horizontal) Plain.

I Call this Plain *Vertical*, because the Pole thereof is in the *Zenith* or *Vertex* of the place. although the Plain it self lie in the Plain of the *Horizontal Circle*. And I not only denominate this, but all the other Plains following, by that part of the Sphere in which the Poles and not the Plains themselves lie. But howsoever the Plain be termed, whether *Vertical* or *Horizontal*, the making of the Dial is still the same. And may be made in any known Latitude by the precepts following.

Example of a Vertical or Horizontal Plain in the Latitude of London 51. deg. 32. min.

First, Draw a Circle *E, S, W, N*, which circle let represent your vertical Plain, crosse it in the middle thereof at right angles with the two diameters, viz. *S, Q, N*, for the Meridian, and hour-line of 12, and *E, Q, W*, for the Prime Vertical or hour-line of 6.

Secondly, Because the Latitude of the place is 51. deg. 32. min. take 51. deg. 32. min. out of your line of chords, and set that distance from *W* to *a*, and from *W* to *b*.

Thirdly, Lay a Ruler from *E* to *a*, and it will cut the Meridian line *S N*, in the point *P*, which point *P* is the

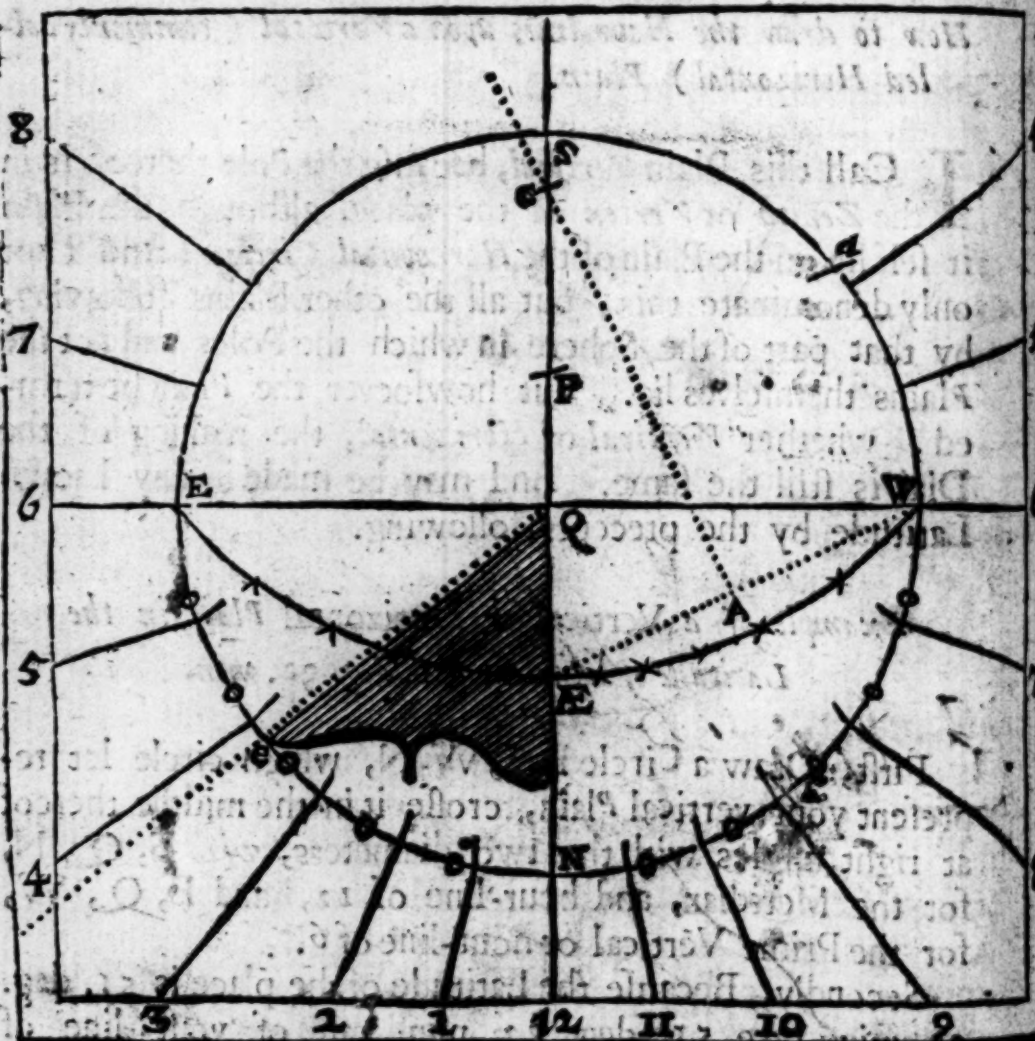
F 2

pole

Horizontal Dial 36 Geometrical Dialling.

3..7½
6..15
9..2
11..50
15..7
10..5
21..12
24..20
27..45
31..11
34..37
30..3
41..56
45..49
49..42
53..35
57..20
62..21
66..44
71..00
75..51
80..34
85..17
90..

A Vertical or Horizontal Dial for the Latitude of London, 51. deg. 32. min.



pole of the world. And a Ruler laid from E to b will cut the Meridian in the point A, so is A the point where the Equinoctial crosseth the Meridian; and thus have you three

three points, *viz.* E, A, and W, through which you must draw the Equinoctial Circle E, A, W, whose centre will alwayes be in the Meridian line S N. So that you may easily find it, as hath been before taught, and in this manner also. Draw the line A, W, which divide in two equal parts in the point A, upon which point A raise the perpendicular A, C, cutting the Meridian S, N, in the point C, which is the centre of the Equinoctial Circle E, A, W, upon which point, and the distance A, C, you may describe it.

Fourthly, Divide the Semicircle E, N, W, into 12 equal parts at the points $\odot \odot \odot$, &c. beginning at the point N, and setting fix on either side thereof. The Semicircle may easily be divided into 12 parts in this manner, for 60. deg. of the line of Chords will divide it into three equal parts, and 30. degr. will divide each of them into two that is 6 equal parts, and 15. degr. is the half thereof, which is a twelfth part of the Semicircle.

Fifthly, Lay a Ruler to Q, the centre of the Plain, and upon every of these points $\odot \odot \odot$, and the Ruler will cut the Equinoctial E, A, W, in the points *, &c. dividing that into 12 unequal parts.

Sixthly, A Ruler laid to P, the Pole of the World, and the several points *, &c. upon the Equinoctial, will cut the Circle representing the plain in the points |||, &c. Semicircle E, N, W, into 12 other unequal parts.

Lastly from the point Q, and through the several points |||, &c. draw straight lines, as Q | 7, Q | 8, Q | 9, &c. they all be the true hour-lines for such a Vertical or Horizontal Plain. Namely for twelve of them, that is from fix in the morning, till fix at night.

But for the hours before, and after fix, that is, for 4 and 5 in the morning, and for 7 and 8 at night, they are

to be drawn by extending the hour-line of 7 and 8 in the morning through the centre Q , and drawing them on the other side of the Plain, so shall they be the hours of 7 and 8 at night; — Also the hour-lines of 4 and 5 in the Evening, being drawn through the centre Q , will become the hour-lines of 4 and 5 in the morning.

For the stile of this Dial, take 51. deg. 32. min. the latitude of your place out of your line of Chords, and set them from N to e , upon the Circle of the Plain, so shall a line drawn from Q through e , be the Axis or Stile of the Dial, Which may be a thin plate of Brasse, cut exactly to the quantity of the angle eQN 51 deg. 32 min. and set perpendicularly upon the line of 12, or the Meridian SQN , and thus is your Diall finished.

If into this, or any of the following Dials, you have a desire to insert the half hours and Quarters, you may put them in by the very same means, as you did the whole hours but then you must divide the spaces between every of the points $\odot \odot$ into two equal parts, for the half, and into 4 equal parts for the Quarters of hours, and proceed with putting on of them in all respects as you did with the whole hours.

II. Of Upright, or Erect Plains.

C H A P. IV.

THose Plains are said to be Erect or Upright, which stand perpendicular to the Horizon of the Place, whose Vertex or upper part tendeth to the Zenith, and their lower part to the Nadir, and such are the walls of Steeples, Churches, Houses, or the like, against which Dials are made.

Of these Upright or Erect lines, there are two sorts, *via.* Direct, and Declining.

Those Erect or Upright Plains are said to be Direct, which do directly behold either the true East, West, North, or South points of the Horizon, or whose Poles do lie directly in either of them, and these Plains are called *Erect direct Plains*.

Those Erect or Upright Plains are said to decline, which do not lie in, nor directly behold any of these points, but are situate under some other Azimuth, as South East, North-West, North-East, &c. and these Plains are called *Erect or Upright declining Plains*. Of both which sorts I shall give you examples. And,

I. of

I. Of Upright, or Erect Direct Plains.

CHAP. V.

How to draw the Hour-lines upon a Direct South Plain.

That Plain is called, by me, a direct South Plain, which lieth in the prime Vertical Circle, or East and West Azimuth, and whose Pole is in the South Part of the Meridian, the making whereof differeth nothing from that going before. Only for the height of the stile, instead of the Latitude you must take the complement thereof.

Example of a Direct South Plain, in the Latitude of London, 51. deg. 31. min.

First, Draw a Circle Z, E, W, N, Representing an upright Direct South Plain, Crosse it at right Angles with the diameters ZQ N for the Meridian, or hour-line of 12, and WQE for the prime vertical Circle, or hour-line of six.

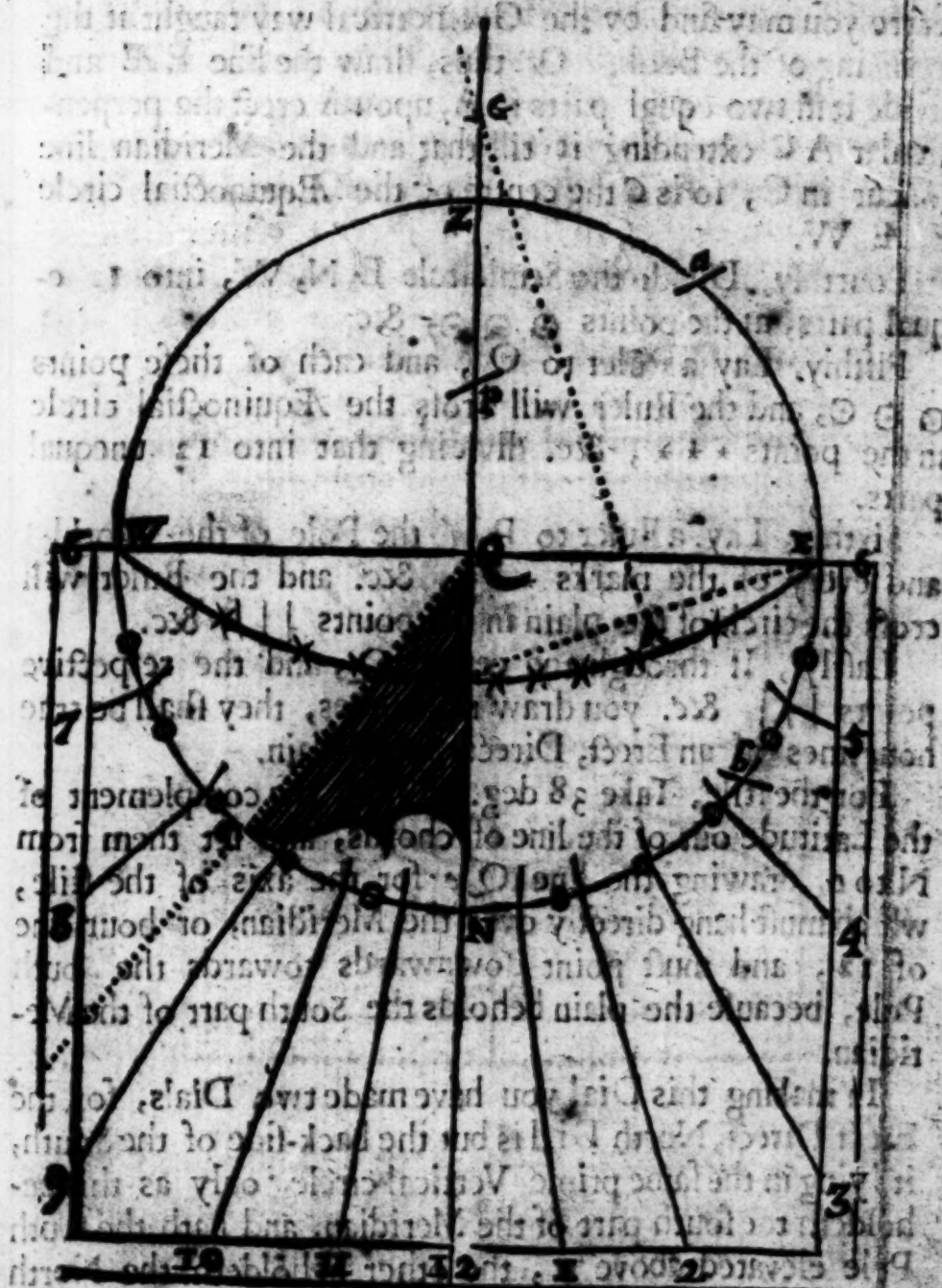
Secondly, Out of your line of chords take 38. deg. 28. min. (which is the complement of the Latitude of the place) and set that distance upon the Dial plain, from Z to *a*, and from E to *b*, and from N to *c*.

Thirdly, Lay a Ruler from W to *a*, it will cut the Meridian ZN, in the point *P*, the pole of the World; and a Ruler also laid from W to *b*, will cut the Meridian in *E* so is *E* the point through which the Equinoctial must passe

Geometrical Dialling.

An Erect direct South Plain.

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passé; and for the drawing of it you have three points given, viz. E, A, and VV, and the Centre will alwayes be in the Meridian line ZN (extended if need be). The centre you may find by the Geometrical way taught at the beginning of the Book. Or thus, draw the line EÆ and divide it in two equal parts in A, upon A erect the perpendicular AC extending it till that and the Meridian line concur in C, so is C the centre of the Æquinoctial circle E, A, W.

Fourthly, Divide the Semicircle E, N, W, into 12 equal parts, at the points ☉ ☉ ☉, &c.

Fifthly, Lay a Ruler to Q, and each of these points ☉ ☉ ☉, and the Ruler will cross the Æquinoctial circle in the points * * *, &c. dividing that into 12 unequal parts.

Sixthly, Lay a Ruler to P, (the Pole of the World) and every of the marks ☉ ☉ ☉, &c. and the Ruler will cross the circle of the plain in the points |||, &c.

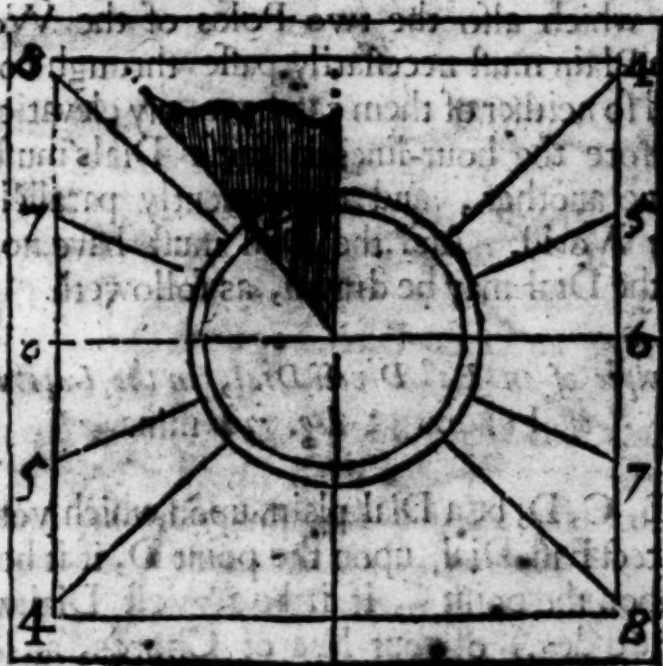
Lastly, If through the centre Q, and the respective points |||, &c. you draw right lines, they shall be the hour lines of an Erect, Direct, South Plain.

For the stile, Take 38 deg. 33 min. the complement of the Latitude out of the line of chords, and let them from N to c, drawing the line Qc for the axis of the stile, which must hang directly over the Meridian, or hour line of 12, and must point downwards towards the South Pole, because the plain beholds the South part of the Meridian.

In making this Dial you have made two Dials, for the Erect Direct, North Dial is but the back-side of the South, it lying in the same prime Vertical circle, only as this beholdeth the south part of the Meridian, and hath the South Pole elevated above π , the other beholdeth the North

part of the Meridian, and half the North Pole elevated above it, and as the Meridian line Z, Q, N, in the South dial, representeth the 12 a clock hour line at noon, the backside thereof (namely the North side) representeth the hour line of 12 at midnight, and therefore is not expressed, neither the hours of 9, 10, 11, or of 1, 2, 3, the Sun to us never being above the Horizon at those hours wherefore the North Dial is only capable of receiving these hours, namely 4, 5, 6, 7, and 8, in the morning, and of 4, 5, 6, 7, and 8, at night, and (in this latitude) not

An Erect Direct North Plain.



of all them neither; for it will never shine upon this plain at 8 in the morning, nor at 4 in the afternoon, but it is best to put them on, as in the figure above, that thereby you

may know how much it is past 7 in the morning, and how much it wants of 5 in the afternoon.

C H A P. VI.

How to draw the Hour-lines upon an Erect, Direct, East, or West Plain.

I Call that an East or West Plain, which lies in the Meridian of the place; and whose Poles lie in the prime vertical circle, or Azimuth of East or West.

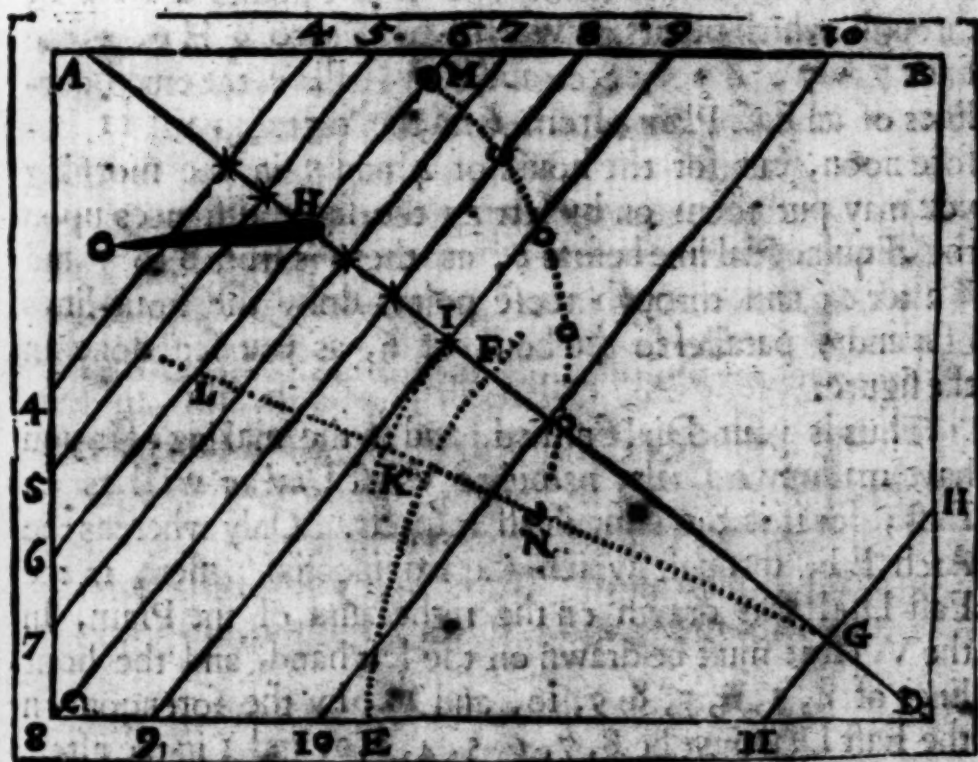
Now forasmuch, as the Plain lieth in the very Meridian Circle, in which also the two Poles of the World are seated, the Plain must necessarily passe through both these Poles, and so neither of them can have any elevation above it; wherefore the hour-lines in these Dials must be parallel to one another, and consequently parallel to the axis of the World. And the Dial must have no centre, however, the Dial may be drawn, as followeth.

Example of an East Direct Dial, in the Latitude of London 51 deg. 32 min.

Let A, B, C, D, be a Dial plain, upon which you would draw a Direct East Dial, upon the point D, if it be an East Dial, or upon the point C, if it be a West Dial with the Radius (or 60 deg.) of your line of Chords, an obscure arch of a circle E, F, then from your chord take 38 deg. 28. the complement of the Latitude of the place, (which is also the height or elevation of the Equinoctial) and set them from E to F, and draw the line D-F quite through the Plain. Then, that you may proportion your stile to your

your plain, so that you may bring on all the hours from Sun rising to 11 a clock, assume two points in the line F D, one towards the end D (as the point G) for the hour-line of 11, and another at H, for the hour-line of 6, and through the points G and H, draw the lines 11 G 11,

An Erect, Direct, East Dial.



and 6 H 6, perpendicular to the *Æquinoctial* line D E. This done, upon the point G, with 60 deg. of the line of chords, describe an obscure arch of a circle I K, and set thereon 15 deg. of your line of chords from I to K, and draw the line G K to cut the line 6 H 6 in the point

so shall LH be the height of the perpendicular stile proportioned to this plain.

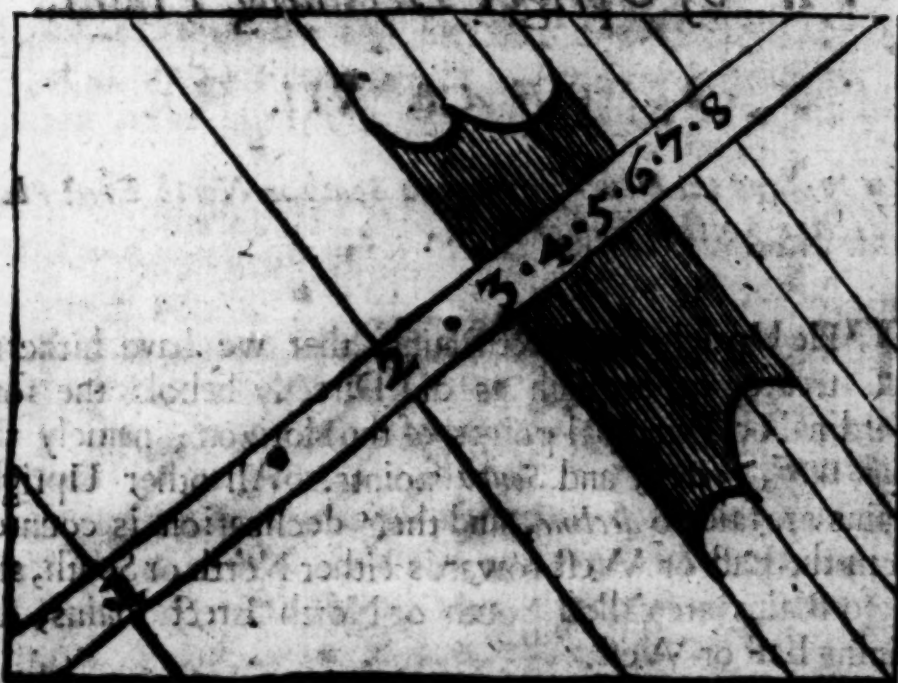
Now for the drawing of the hour-lines set one foot of the Compasses (opened to 60 deg. of the chord) in L , and with the other describe the arch of a circle MN , betwixt the hour-line of 6, and the line GL . Which divide into 5 equal parts in the points $\odot \odot \odot \odot \odot$, and a Ruler laid from the point L , to each of these points $\odot \odot \odot$, &c. will cut the *Æquinoctial* line HD in the points $*****$, through which points draw lines parallel to $6H6$, as the lines $7*7$, $8*8$, &c. and they shall be the true hour-lines of an East Plain, from 6 in the morning till 11 before noon, but for the hours of 4 and 5 in the morning you may put them on by setting the same distances upon the *Æquinoctial* line before 6, as there is from 6 to 7 and 8 after 6, and through those points draw the hour-lines of 4 and 5 parallel to the hour of 6, as you see done in the figure.

Thus is your Dial finished, and in the making of it you have made two Dials, namely a West Dial as well as an East, for it is the same in all respects. Only whereas the Arch EF , through which the *Æquinoctial* passeth in the East Dial was drawn on the right hand of the Plain, In the West it must be drawn on the left hand, and the hour lines of 4, 5, 6, 7, 8, 9, 10, and 11, in the forenoon on the East Dial must be 8, 7, 6, 5, 4, 3, 2, and 1 in the afternoon, upon the West Dial, as in the figure appeareth.

Geometrical Dialling.

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An Erect, Direct, West Dial



The **Stile** of these East or West Dials, may be either a straight Pin of the just length of the line HO , which is equal to HL in the East Dial, fixed in the Point H , upon the hour-line of six, and exactly perpendicular to the plain, shewing the hours by the shadow of the very top thereof.

Or, it may be a plate of brass of the same breadth with the distance between the hours of 6 and 8, which Plate must be set perpendicular upon the hour-line of six, and so it will shew the hour by the shadow of the upper edge thereof, as in the West Dial.

These five Dials here described, viz. the **Vertical**, the **South**, **North**, **East**, and **West Erect, Direct**, may be made upon a Stone cut square in form of a Die, which Body is called a **Cube**.

II. of

I I. Of Upright Declining Plains.

C H A P. VII.

How to draw the Hour-lines upon a South or North Erect Plain Declining either East or West.

THe Upright or Erect Plains, that we have hitherto treated of, are such as did Directly behold the four Cardinal or Principal points of the Horizon; namely the East, West, North, and South points. All other Upright Plains are said to *decline*, and their declination is counted from the East or West towards either North or South, and these Plains are called South or North Erect Plains, declining East or West.

Before the hour-lines can be drawn upon any of these plains: two things must be given, and three other things must be found:—

The Things given must be,

1. The Latitude of the Place.

2. The Declination of the Plain.

The Things required are

1. The height of the Pole (or Stile) above the Plain.

2. The distance of the Sstile from the Meridian or 12 a clock hour-line.

3. The Plains difference of Longitude.

For the finding of these we must project upon the Plain such circles of the Sphere (in their true positions) as are requisite for the finding of them, and those circles are, the Horizon, the Meridian, and the Equino-
ctial:

daily which shall show him his position by giving him

Example of a South Erect Plain, declining Westward 24 deg.
20 min. in the Latitude of London 51 deg. 32 min.

		d.	m.
Data	Latitude of the Place	51	32
	Declination S. West	24	20

		d.	m.
Quesita	Distance of the Substile from the Merid.	18	8
	Height of the Pole (a stile) above the Plain	34	33
	Plains difference of Longitude	30	00

To find which.

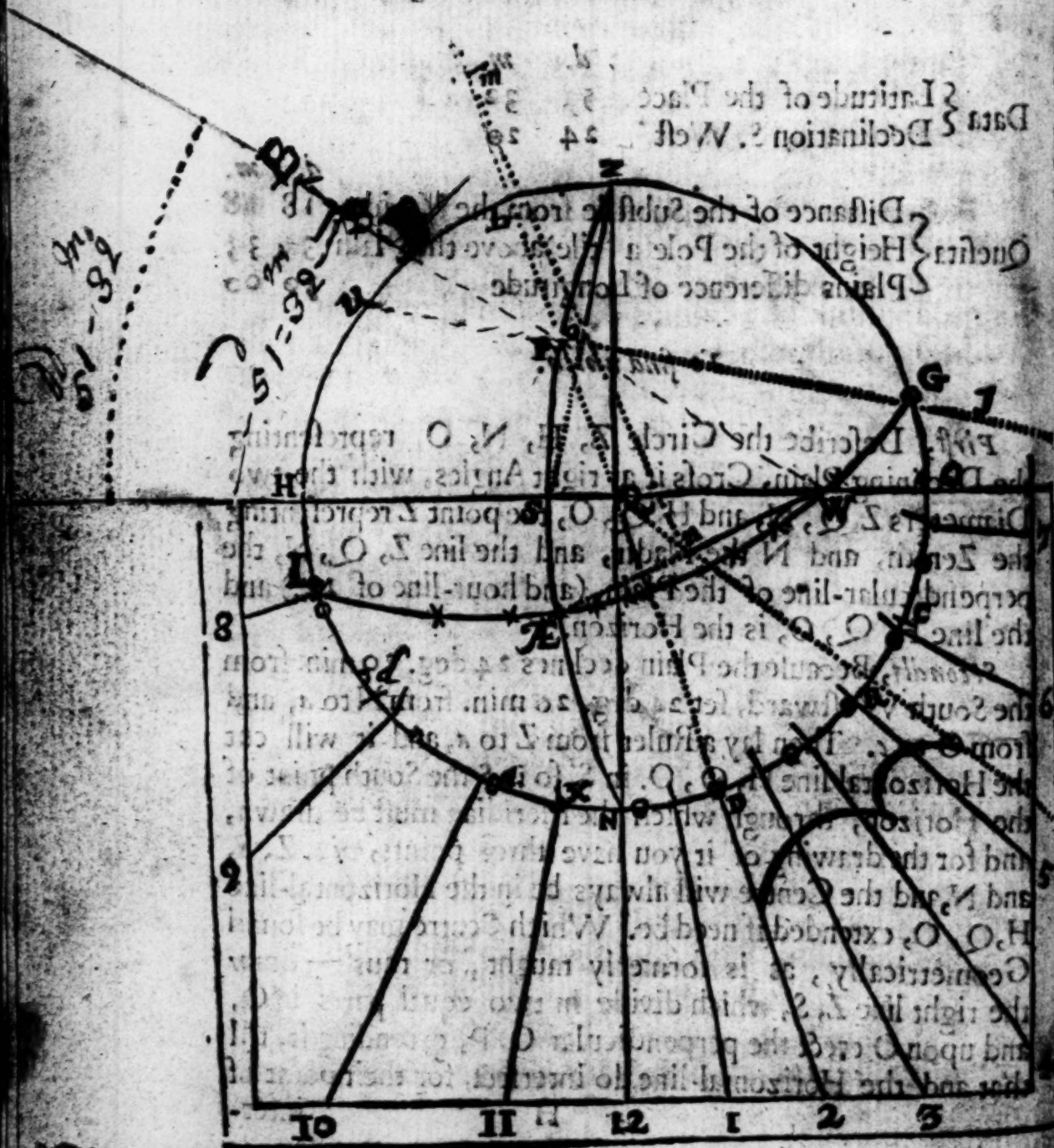
First, Describe the Circle Z, H, N, O, representing the Declining Plain, Cross it at right Angles, with the two Diameters Z, Q, N, and H, Q, O, the point Z representing the Zenith, and N the Nadir, and the line Z, Q, N, the perpendicular-line of the Plain, (and hour-line of 12.) and the line H, Q, O, is the Horizon.

Secondly, Because the Plain declines 24 deg. 20 min. from the South Westward, set 24 deg. 20 min. from N to a, and from O to c. Then lay a Ruler from Z to a, and it will cut the Horizontal line H, Q, O. in S, so is S the South point of the Horizon, through which the Meridian must be drawn, and for the drawing of it you have three points, viz. Z, S, and N, and the Centre will always be in the Horizontal-line H, Q, O, extended if need be. Which Centre may be found Geometrically, as is formerly taught, or thus — draw the right line Z, S, which divide in two equal parts in O, and upon O erect the perpendicular O, P, extending it, till that and the Horizontal-line do intersect, for their point of

S . . . S I H II of inter-

An Upright Plain Declining from the South
Westward 24 deg. 20 min.

Example of a Dialling Plate declining Westward 24 deg. 20 min. in the Latitude of London 51 deg. 32 min.



intersection shall be the Centre of the Meridian. Then lay a Ruler from Z to c, and it will cut the Horizon in W, the West point thereof.

Thirdly, Having drawn the Meridian and the Horizon, take 51 deg. 32 min. out of your line of hords, and set them upon your Plain, from H to B, and from N to d.

Fourthly, Lay a Ruler upon W, the West point of the Horizon, (which is also the Pole of the Meridian) to b, and it will cut the Meridian in the point P, so shall P be the Pole of the World, through which point P and Q (the Pole of the Plain) draw the straight line B, P, Q, D, representing the Axis of the World, and the Subtilar line of the Dial.

Fifthly, Lay a Ruler from W to d, and it will cross the Meridian in the point E, so is E one point in the Meridian, through which the Equinoctial must pass: And the Point W in the Horizon is another. So have you two points within the Circle, by which to draw the Equinoctial, which you may do Geometrically, as is before taught. Or you may find it thus. The Centre of the Equinoctial will always be in the Axis of the World, and therefore, in the line B, P, Q, D. Now to find the point, draw the line E, W, which divide in two equal parts in the point n, upon n erect a perpendicular, till it cut the Axis of the World, extended in m. So m is the Centre of the Equinoctial, upon which point you may describe it. And thus have you drawn upon your plain, all the three Circles required, viz. the Horizon, Meridian, and the Equinoctial; by which may be found the three requisites belonging to this plain. For,

1. To find the height of the Pole above the Plain, represented in the Scheme by the line P, B. Lay a Ruler to G, where the Equinoctial cuts the Plain, and to P the Pole of the World, the Ruler will cut the Plain on

the opposite side in the point v . So the distance from B to v , measured upon the line of Chords, will be found to contain 34 deg. 33 min. The height of the Pole above the Plain.

2. To find the distance of the Substile from the Meridian, represented in the Scheme by the Arkes Z , B , or N , D . Take in your Compasses the distance Z , B , or N , D , and you shall find either of them equal to 18 deg. 8 min. and such is the distance of the Substile from the Meridian.

3. To find the Plains difference of Longitude, Represented in the Scheme by the Angle A , P , K . Lay a Ruler from P to A , it will cut the Plain in x , so the distance between D and x , measured upon the line of Chords, will be 30 deg. And such is the Plains difference of Longitude.

Lastly, These Requisites being obtained, we come to the drawing of the hours: to effect which, lay a Ruler to P , the Pole of the World, and E , the Intersection of the Equinoctial with the Meridian, and it will cut the Plain in the point x . — At this point x begin to divide the Semicircle L , x , G , into 12 equal parts, at the point $\odot \odot \odot \odot$. Then laying a Ruler to Q , and every of these points $\odot \odot \odot \odot$, it will cut the Equinoctial Circle dividing that into 12 unequal parts in the points $x x x x \odot$. Again, a Ruler laid to P , and every of these unequal parts $x x x x \odot$, will divide the Plain into 12 unequal parts in the points $| | | | \odot$. — Lay a Ruler to Q , and every of these points, $| | | | \odot$, drawing lines by the side thereof, and they shall be the true hour-lines proper to such a declining Plain.

Thus have you finished the hour-lines, the substilar-line, (or the line upon which the Style must stand) is the line Q , D ,

D, falling (in this Dial) just upon the hour-line of 2 in the afternoon, because the Plain declined Westward. The Angle of the Stile is D, Q, R, containing 34 deg. 33. min. and must be either of Plate or Wyre brought to such an Angle, and must stand perpendicular to the Plain, and directly over the Substilar Q, D.

Now have you finished your Dial, and in so doing you have in this one, made four Dials, viz.

1. South declining West

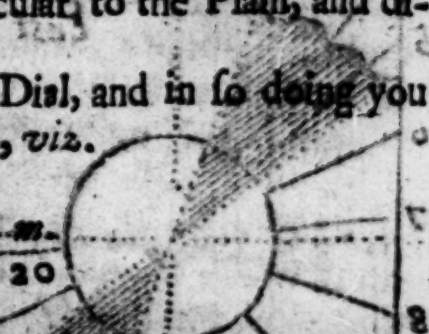
2. South declining East

3. North declining West

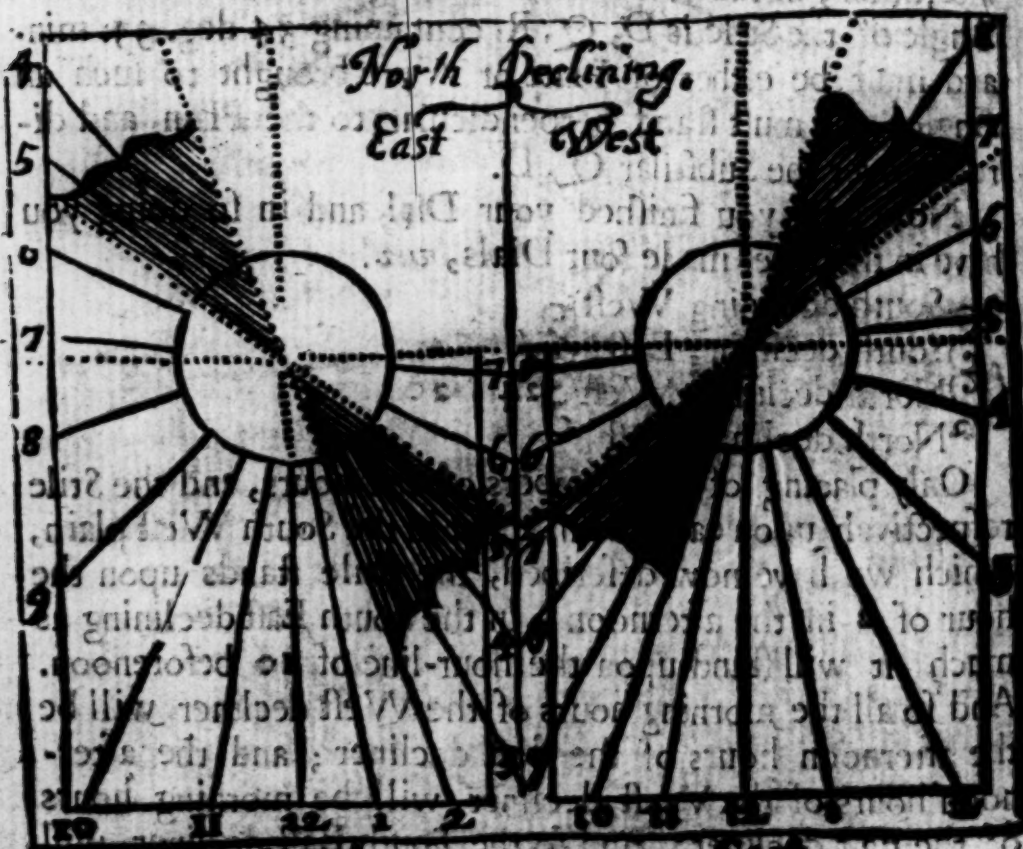
4. North declining East

Only placing of the numbers of the hours, and the Stile respectively upon each Plain. For in the South West plain, which we have now described, the Stile stands upon the hour of 2 in the afternoon; in the South East declining as much, it will stand upon the hour-line of 10 beforenoon. And so all the morning hours of the West decliner, will be the afternoon hours of the East decliner; and the afternoon hours of the West decliner, will be morning hours of the East decliner: And so the South East decliner, will produce the North West decliner, and the South West decliner, the North East decliner, by only extending the hour lines, Stile and Substile quite through the Centre. And that there may yet remain no doubt, I have drawn all the four Dials in one, by which you may plainly see that there is no difference between them, but what hath been already intimated.

the directions following.



The four upright Declining Dials.



By this Figure you may plainly see how that one Dial is the Product of all these four, by observing the cautions before delivered. So that it may seem superfluous to say any more concerning these upright declining Dials. Only before I leave them, I will (because these Dials are most in use) give you one other Example of an upright declining Plain, which by reason of its great Declination from the Prime Vertical, or its Poles great deviation from the Meridian, causeth the Pole to have but small Elevation, wherefore the Dial (as all such like) must be drawn without a Centre, by the directions following.

CHAP.

C H A P. VIII

How to draw the hour-lines upon upright far declining Plains, which by reason of the small elevation, which the Pole hath over such Plains, the hours (if they be drawn from a Centre) cannot be of any competent distance one from another.

THose Plains which lye near to the Meridian Circle, and whose Poles (consequently) near the Prime Vertical Circle, or Azimuth of East or West; the Pole hath but small elevation above such Plains, so that the hour-lines (especially those of them which fall near to the Substile) from the Centre, cannot be drawn at any competent distance, without a large extension of them. To remedy which inconvenience, you may draw the hour-lines for such a Plain at a convenient distance, and in a little room, without any regard had to the Centre. But before you proceed to draw the Dial, you must first find the three requisites mentioned in the last Chapter, viz.

1. *The height of the Pole above the Plain.*
2. *The distance of the Substile from the Meridian.*
3. *The Plains difference of Longitude.*

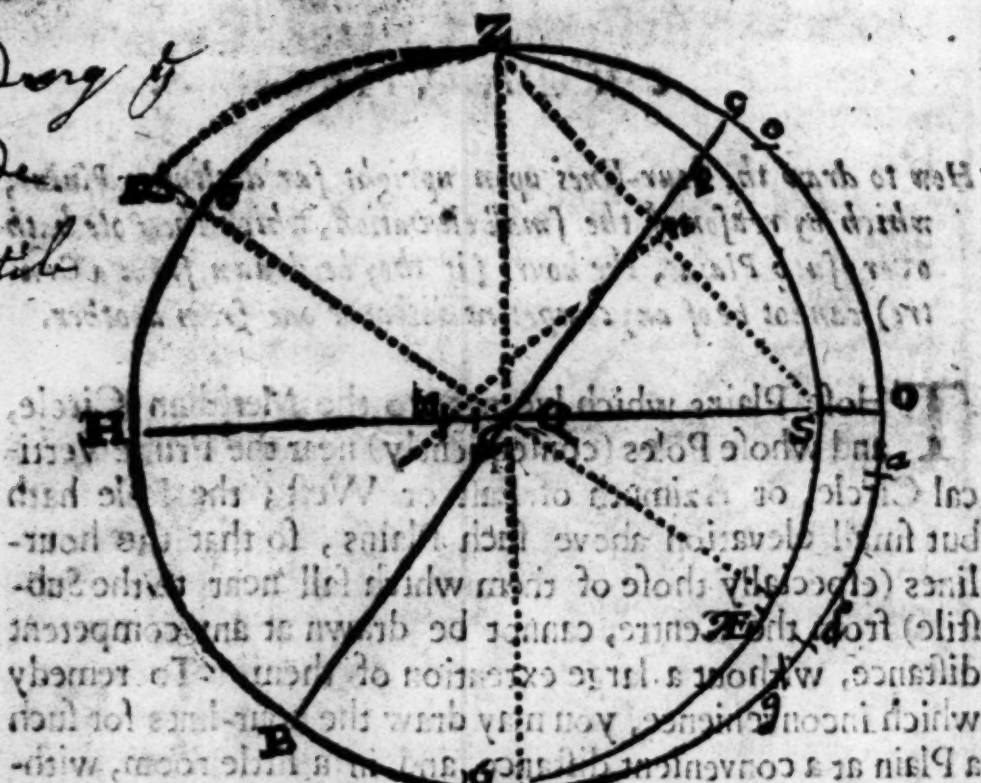
Example of an upright South Plain, declining Eastward 20 deg. in the Latitude of London 51 deg. 32 min.

To find these Requisites.

First, Draw the Circle Z, H, N, O, crossing it with the diameters Z, N, the perpendicular and H, O, the Horizontal line of the Plain.

Secondly,

for finding of
Longitude
& Substile



Secondly, Because the Plain declineth 80 deg. Eastward, set 80 deg. from N to a, and from H to b.

Thirdly, Lay a Ruler to Z and a, it will cut the Horizon in S, the South point thereof, and a Ruler laid to Z and b, will cut the Horizon in E, the East point thereof.

Fourthly, Having the three points Z, S, and N, through them draw the Meridian Z, S, N, whose Centre (by any of the wayes before taught) will be found to be at m.

Fifthly, Out of your Line of Chords take 51 deg. 32 min. the Latitude, and set them from O to c, and from N to d. Then laying a Ruler from E to c, it will cut the Meridian in P, the Pole of the World; through which point P, and Q, the Centre of the Plain, draw the right line P, Q, B, for the Axis of the World. Also, the Ruler laid from E to

How to draw the hour-lines upon the Plain.

First, Draw a right-line A, B, for the perpendicular-line of your Plain, and upon A as a centre, with 60 deg. or the Radius of your Chord, describe an obscure Arch of a Circle C, D, E, and thereon from C to D, set 38 deg. 4 min. the Substiles distance from the Meridian before found, and draw the line A, D, for the Substile, quite through the Plain.

Secondly, Take 6 deg. 12 min. the height of the Pole above the Plain from your Chord, and set them upon the Arch from D to E, and draw the line A, E, for the Stile.

Thirdly, Forasmuch as the Stile A, E, in this case is but of small Elevation, viz. but 6 deg. 12 min. Draw the line G, H, parallel to A, E, at such convenient distance, as you shall think fit, for your new (or augmented) Stile to stand from your Substile A, D.

Fourthly, Assume any two points in the Substile A, D, as R and S, and through these two points draw two infinite right lines, both of them at Right-angles to the Substilar-line A, D, as the lines Z, Z, and X, X.

Fifthly, From the point R, take with your Compasses the least distance to the new augmented Stile G, H; and set that distance upon the Substilar line, from R to K: Also, from the point S, take the least distance to the new Stile G, H, and set that distance also upon the Substilar-line from S to L.

Sixthly, Upon the two Points K and L, (as upon two Centres) with 60 deg. or the Radius of the line of Chords, describe two Circles, and in either of them set off 82 deg. 8 min. the Plains difference of Longitude, as from S to M, and from R to M, both on the same side of the Sub-

stilar-line, on which the perpendicular-line of the Plain A, B, was drawn.

Seventhly, Divide either of the Semicircles last drawn, into twelve equal parts, at the points $\odot \odot \odot \odot \odot \odot$, beginning this division in either of them, at the point-M.

Eighthly, Lay a Ruler to the point L, and every of the divisions $\odot \odot \odot \odot \odot \odot$, and the Ruler will cut the Contingent, or Equinoctial-line X, X, in the points X, X, X, X, X, X. Also a Ruler laid to K, and each of the points $\odot \odot \odot \odot \odot \odot$, will cut the other Contingent line Z, Z, in the points X, X, X, X, X, X.

Lastly, Lines drawn from the point * in one Contingent line, to the point * in the other Contingent line, each to his correspondent (which the Substilar-line will direct you how to do) those lines shall be the true hour-lines belonging to such a Declining Plain, and be drawn as in the Figure you see done, at a competent distance one from another, without any relation at all had to the Centre of the Dial.

Thus have you finished your Dial, and in the making of this, you have made a South Declining West 80 degrees also; for if you turn the Paper, and look through it, it will on the back-side be a South Declining West 80 degrees only the forenoon hours in this, must be the afternoon hours in that: Nay, in rigour, you have in this one Dial made four, viz. a North declining either East or West, if you well observe what was said and done in the last Chapter.

And thus have I done with all Upright, or Erect Plains, either Direct or Declining. I shall now proceed to shew you how to inscribe Hour-lines upon such Plains as are not Upright, but Recline from the Zenith, and of them there are such as are Direct, and such as do Decline.

Of Reclining Plains.

I. OF EASTWARD RECLINING.

AS in upright Plains there were two varieties, viz. Erect Direct and Erect Reclining. So are there of Reclining Plains also. For such Reclining Plains as do directly behold, either the true East, West, North, or South points of the heavens, that is, those Poles lye, either in the Meridian or Prime Vertical Circle of the place, are called *Direct Reclining Plains*.

Again, Those Reclining Plains, which do not directly lye in, or their Poles be not in the Prime Vertical, or Meridian Circles of the place, but deviate therefrom, are called *Declining Reclining Plains*. Of both which sorts I shall give you an account, and the manner of inscribing hour-lines upon them, for in these plains there is far more variety, than there was in Upright or Erect Plains.

1. The Latitude of the Place.

2. The Reclination of the Plain.

The Reclination of a Plain (as hath been before declared) is the Arch of an Aximuth or Vertical Circle, intercepted between the Zenith of the place, and the Reclining Plain.

Example, of an East or West Plain, Reclining 35 deg. in the Latitude of London 51 deg. 32 min.

4. 30.

35

60

Latitude of the Place

Declination of the Plain 35

of

Of Direct Reclining Plains, &c.

I. Of East and West Recliners.

C H A P. X.
How to draw the hour-lines upon a Direct East or West Reclining or Inclining Plain.

AS in upright declining Dials, two things must be given, and three things must be found, before the hour-lines could be drawn: In these direct Reclining Plains two things must also be given, and three must be found before the Dial can be made.

The things that must be given are,

1. The Latitude of the Place.
2. The Reclination of the Plain.

The Reclination of a Plain (as hath been before declared) is the Arch of an Azimuth or Vertical Circle, intercepted between the Zenith of the place, and the Reclining Plain.

Example, of an East or West Plain, Reclining 35 deg. in the Latitude of London 51 deg. 32 min.

		d.	m.
Data	Latitude of the Place	51	32
	Reclination of the Plain	35	00

Quæsitæ

Geometrical Dialling

63

The height of the Pole above the Plain.
 Quæsitæ { The distance of the Substile from the Meridian.
 { The Plains difference of Longitude.

First, Draw the Circle N, E, S, R, representing the Reclining Plain, and cross it with the two Diameters, N, Q, S, the Horizontal-line of the Plain, and hour-line of 12 a clock, and E, Q, R, the Prime Vertical.

Secondly, Because the Plain Reclines 33. deg. take 33 deg. out of your line of Chords, and lay them from E to a, and from N to b.

Thirdly, Lay a Ruler from S to a, and it will cut the Prime Vertical Circle in Z, so is Z the Zenith of the Place — Also a Ruler laid from S to b, will cut the same Vertical Circle in W, by which point the Horizon of the Place must be drawn.

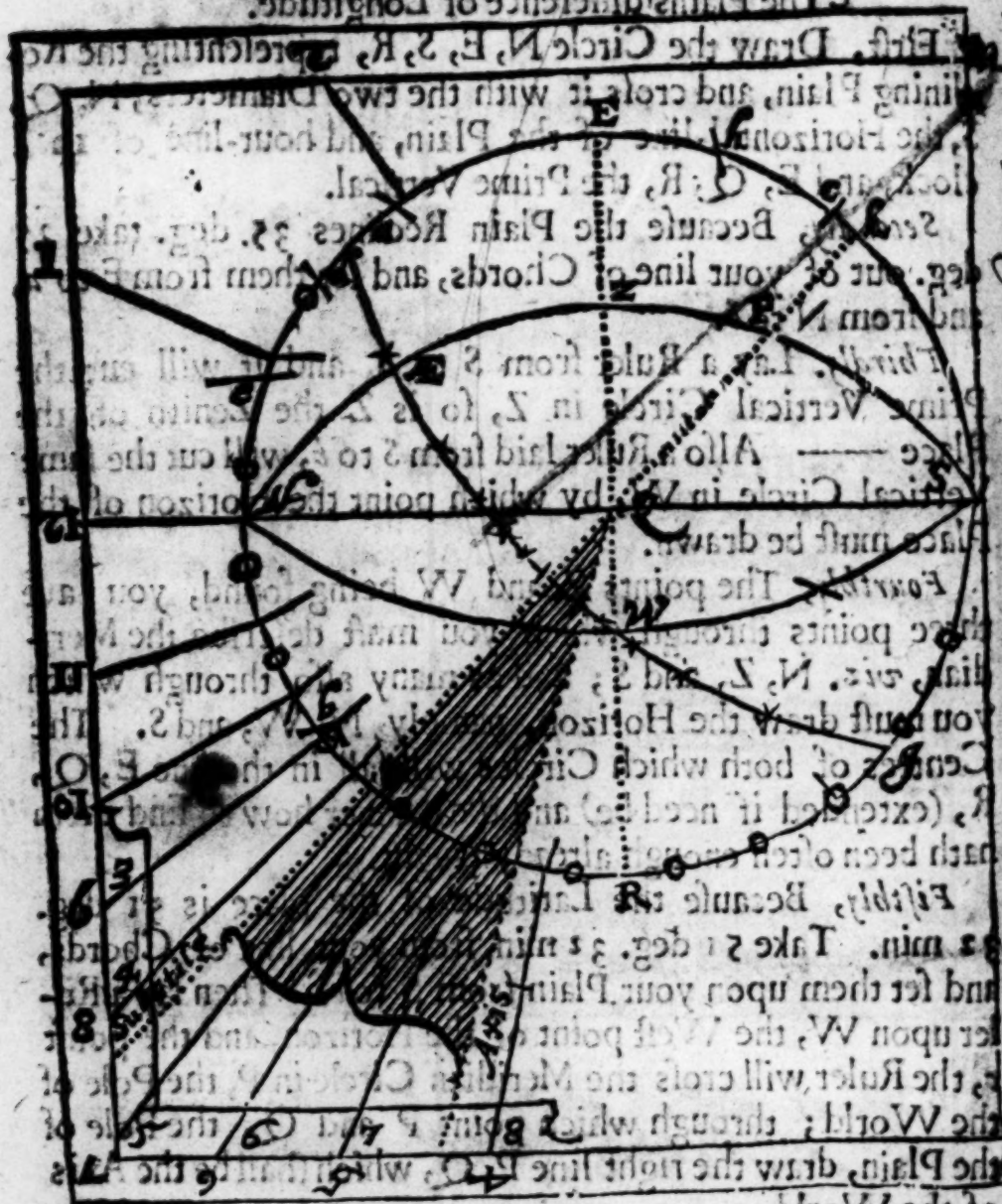
Fourthly, The points Z and W being found, you have three points through which you must describe the Meridian, viz. N, Z, and S; and as many also through which you must draw the Horizon, namely, N, W, and S. The Centres of both which Circles will fall in the line E, Q, R, (extended if need be) and the manner how to find them hath been often enough already taught.

Fifthly, Because the Latitude of the place is 51 deg. 32 min. Take 51 deg. 32 min. from your line of Chords, and set them upon your Plain from S to c. Then lay a Ruler upon W, the West point of the Horizon, and the point c, the Ruler will cross the Meridian Circle in P, the Pole of the World; through which point P and Q, the Pole of the Plain, draw the right line P, Q, which shall be the Axis of the World.

Sixthly, Take 90 deg. of your line of Chords, and set them upon the Circle of your Plain from c to d, then lay a Ruler from W to d, and it will cut the Meridian Circle in E,

East and West Inclining.

Question. The distance of the Substile from the Meridian.
The Plain distance of Longitude.



So is A one point in the Meridian, through which the Equinoctial Circle must be drawn, and W the West point of the Horizon is another; so have you two points within the

the Circle, through which you must describe the Equinoctial, whose Centre will be in the line P, Q, the Axis of the World, (extended if need be) the manner how to find it hath been already taught several ways.

Having thus projected the *Meridian Horizon*, and *Equinoctial*, you may find the three Requisites, as followeth,

1. *To find the height of the Pole above the Plain P, c.* Lay a Ruler to g and P, it will cut the Plain on the opposite side in h; so k, h, measured upon the Chords, will be 26 deg. 41 min. the height of the Pole above the Plain.
2. *To find the distance of the Substile from the Meridian S, k.* Take S, k, in your Compasses, and measure it upon the Chord, it will be found 45 deg. 52 min. the distance of the Substile from the Meridian.
3. *To find the Plains difference of longitude, A, P, O.* A Ruler laid from P to A, will cut the Plain in e, the distance from O the Substile, to e will give 66 deg. 27 min. of the Chord, which is the Plains difference of longitude.

These Requisites being obtained, you may proceed to find the home distances upon the Plain in this manner.

Seventhly, Lay a Ruler to P the Pole, and A the intersection of the Meridian with the Equinoctial, and it will cut the Plain in e. At e begin to divide the Semicircle into 12 equal parts, at the points $\odot \odot \odot \odot c$.

Eighthly, Lay a Ruler to Q, and the several points $\odot \odot \odot \odot c$. and it will cut the Equinoctial Circle in the points x, x, x, &c. dividing that into 12 unequal parts.

Ninthly, Lay a Ruler to P, and the several points x, x, x, &c. and it will cut the Plain in the points | | |, &c.

Lastly, If from the Centre Q, you draw right lines through the points | | |, &c. they shall be the true hour

hour-lines belonging to your Reclining Plain.

And thus have you finished your Dial, and also in it four Dials: For the Dial as it here stands in the Scheme, is properly an East and West Incliner, but being turned upside down, as you see the hours numbred, and the word Zenith standing upwards, it is an East Recliner; and if the hour-lines be turned (or supposed to stand) on the right hand of the Prime Vertical-line, E, Q, R, as in this Scheme they do on the left hand, and the hours of 4, 5, 6, &c. in the Morning, changed to 8, 7, 6, &c. in the Evening, the Plain is then a West Recliner. And if the hour-lines be drawn through the Centre of either of them, the Plains then become East and West Incliners; the hours and Substile in all retaining the same place, only the denominations of the hours changed, &c. you must remember, that in all East and West Recliners, the North Pole is elevated, and in all Incliners (opposite to them) the South Pole.

II. Of South Recliners.

C H A P. XI.

How to draw the hour-lines upon Direct South Reclining, or Inclining Plains.

IN the East and West Reclining and Inclining Plains, before described, the Meridian, or 12 a clock hour-line, did lye in the Horizontal-line of the Plain, and the Poles thereof in the Prime Vertical Circle. So (on the contrary) in these South and North Reclining and Inclining Plains, their Horizontal-line lyeth in the Prime Vertical Circle, or hour of 6, and their Poles in the Meridian, and from hence they receive their denomination. Of

Of these Direct Reclining Plains there are six Varieties, viz. three of South Recliners, and as many of North Recliners. For

1. The South Plain may Recline, so as it may just fall in the Axis of the World, and so pass through the Poles of the World, and then is it called an Equinoctial Plain, because the Poles thereof lye in the Equinoctial Circle, and neither of the Poles have any elevation above it, wherefore the hour-lines must be all Parallel one to the other, and all of them to the Axis of the World, and the Dial must be drawn as the Erect direct East or West Dials were. Only whereas the Stile stood upon the hour-line of 6 in the East and West, in these Plains it must stand upon the hour-line of 12, and be of equal height, with the distance between the hours of 12 and 9, or 12 and 3, which are equidistant from the Meridian.

2. Or *Secondly*, the South Plain may so recline, that it may fall between the Zenith and the North Pole, and then is the South Pole elevated above such Plains. Or,

3. The North Plain may so Recline, that it may fall between the Horizon and the North Pole, and then is the North Pole Elevated.

Examples of these three Varieties of South Reclining Plains.

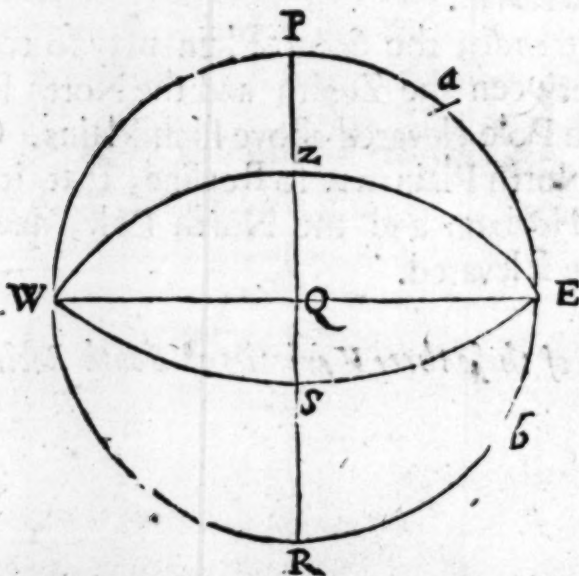
The First Variety.

C H A P. XII.

How to draw the hour-lines upon an Equinoctial Plain: Reclining just to the Pole.

EXample, of a South Plain Reclining 38 deg. 28 min. in the Latitude of *London* 51 deg. 32 min.

First, Draw the Circle W, P, E, R, representing your Reclining Plain, and cross it with the two Diameters P, Z, S, R, for the Meridian, and W, Q, E, the Horizontal-line of the Plain.



Secondly, Because the Plain Reclines 38 deg. 28 min. take 38 deg. 28. min. out of your Chord, and set them from P to *a*. and from E to *b*.

Thirdly,

Thirdly, Lay a Ruler from W to *a*, it will cut the Meridian in Z, so is Z the Zenith of the Place, through which and W and E, the West and East points of the Horizon, draw the Prime Vertical Circle W, Z, E.

Fourthly. Lay a Ruler from W to *b*, and it will cut the Meridian in S, through the points W, S, and E, draw the Horizon of the Place W, S, E.

Fifthly, Because the Latitude of the Place is 51 deg. 32 min. Set 51 deg. 32 min. upon your Plain from E to *a*, and it will cut the Meridian P, Q, R, in the point Z the Zenith, then (because the Pole of the World is removed from the Zenith (always) so much as is the complement of the Latitude, which here in this Example is 38 deg. 28 min. take therefore this distance 38 deg. 28 min. and set it upon your Plain from *a*, and you shall find, that the Compass-point will directly fall in the Point P, which is the Pole of the World, and is the very place where the Reclining Plain, and the Meridian of the place do intersect, which clearly demonstrates, that the Pole hath no Elevation above this Plain. And by this means, the line W, Q, E, becomes to be the Equinoctial, and a straight line, wherefore the hour-lines must be all parallel one to the other, and all of them to the Axis of the World, and the Dial must be drawn in this manner.

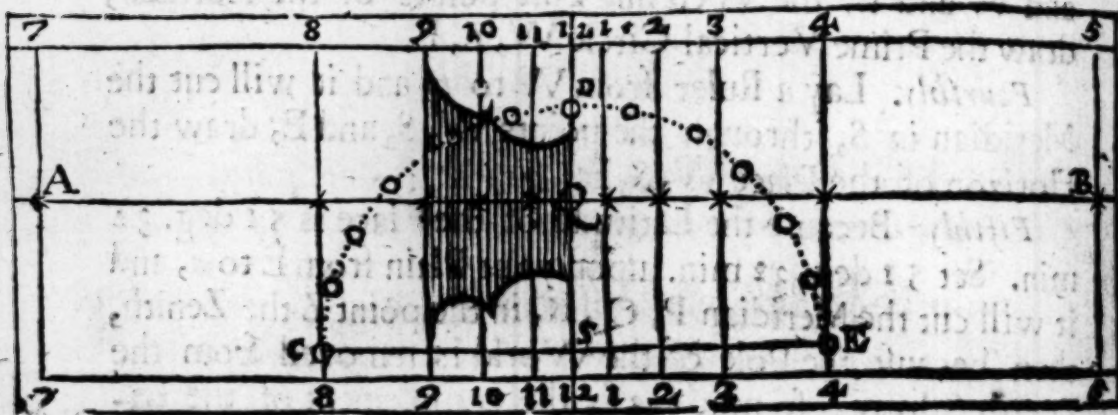
To draw the Hour-lines upon the Plain.

First, Draw the Line A, B, for the Horizontal-line of the Plain, and cross it about the middle thereof at right Angles, with the line 12 Q 12 for the Meridian and hour-line of 12.

Secondly, Upon the line 12 Q 12, either above or below Q assume any point, as S, and setting one foot of your
Com-

Geometrical Dialling

A Direct Equinoctial Dial.



Compasses therein (it being opened to the Radius of your line of Chords) describe the Semicircle C, D, E, which divide into 12 equal parts, beginning (for uniformity sake) at D.

Thirdly, Lay a Ruler to S, and the several points $\odot \odot \odot$, &c. and it will cross the Equinoctial line A, B, in the points x, x, x, &c.

Lastly, Through these points x, x, x, &c. draw right lines, all parallel to the line 12 Q 12, and so is your Dial finished.

The Stile may be either a straight Pin, of the length of the line Q, S, set perpendicular to the Plain, upon the point Q; the shadow of the top thereof only giving the hour. Or it may be a Plate of the breadth of the distance that is between the hour-lines of 12 and 3, or 12 and 9. and then will the shadow of the upper edge thereof, give the hour of the day.

The second Variety.

C H A P. XII.

How to draw the hour-lines upon a direct South Reclining Plain, which falls between the Zenith and the Pole.

Let the Example be of a South Plain, Reclining 25 deg. in the Latitude of London 51 deg. 32 min.

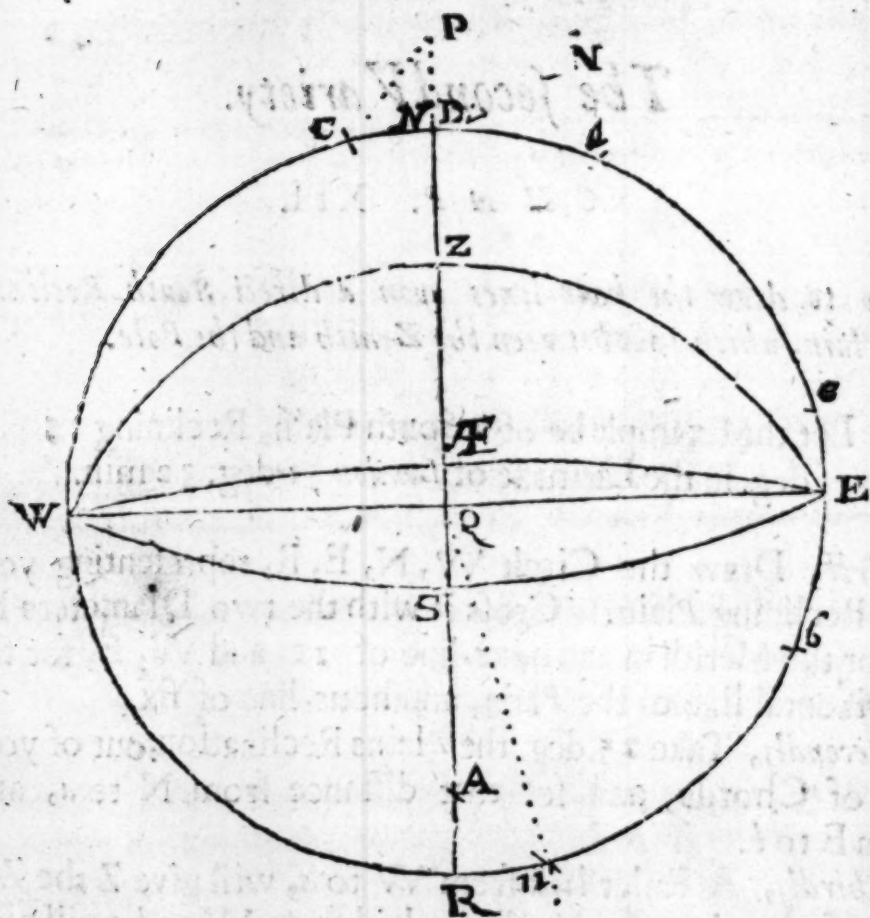
First, Draw the Circle W, N, E, R, representing your Reclining Plain. Cross it with the two Diameters N, R, for the Meridian and hour-line of 12, and W, E, for the Horizontal line of the Plain, and hour-line of six.

Secondly, Take 25 deg. the Plains Reclination, out of your line of Chords, and set that distance from N to *a*, and from E to *b*.

Thirdly, A Ruler laid from W to *a*, will give Z the Zenith of the place; and a Ruler laid from W to *b*, will give S the South point of the Horizon; both which Circles W, Z, E, the Prime Vertical, and W, R, E, the Horizon, may be drawn, as hath often enough already been shewn, their Centres being always in the Meridian line N, Q, R, extended if need require.

Fourthly, Because the Pole of the World is always distant from the Zenith, the Complement of the Latitude of the place, viz. here at London, 38 deg. 28 min. Take (therefore) 38 deg. 28 min. out of your line of Chords, and set them upon your Plain from *a*, the point which found the Zenith to *c*.

Fifthly,



Fifthly, Lay a Ruler from W to c, and it will cut the Meridian N, Q, R, (being extended) in P, so is P the North Pole of the World, and because it falleth without the Plain, it is evident by the Scheme, that this Reclining Plain, passeth through the Meridian, between the Zenith and the Pole. And again, because the North Pole P, falleth without the Plain, it also demonstrates that the South Pole must be elevated above this Plain. Wherefore,

Sixthly, To find the point of the South Pole upon the Meridian line N, Q, R, do thus. Because the two Poles are 180 deg. distant from each other, viz. two Quadrants, or twice

twice 90 deg. Take therefore 90 deg. out of ycur line of Chords, and set them twice upon your Plain from *c*, viz. first from *c* to *e*, and then from *e* to *n*, so shall the 180 deg. end in *n*. And a Ruler being laid from *W* to *n*, shall cross the Meridian in *A*, the South Pole; so is the South Pole *A*, Elevated above the Reclining Plain, the quantity of *A R*, which is equal to the Arch *R n*, which measured upon the line of Chords will be found 13 deg. 28 min.

Seventhly, Lay a Ruler from *W* to *e*, and it will cut the Meridian in *Æ*, so is *Æ* that point in the Meridian through which the Equinoctial must pass. As also through the points *E* and *W*, the East and West points of the Horizon.

Eighthly, For the Hour-lines, They are to be drawn in all respects as the Hour-lines were upon the Upright South Plain, without any alteration, only there the Stile was elevated according to the Complement of the Latitude, 38 deg. 28 min. here it must be elevated only 13 deg. 28 min. as in the Scheme. The manner how the hour-lines are to be put on, I shall only repeat, but I shall forbear drawing them, leaving that to your own practice, in regard there is no alteration at all from the Erect Direct South Plain. Wherefor divide the Semicircle of your Plain *W, R, E*, into 12 equal parts, (beginning at *R*, and so 6 equal parts on either side of the Meridian *N, Q, R*.) Then lay a Ruler to *Q*, and every of those 12 divisions, it will divide the Equinoctial into 12 unequal parts. A Ruler laid from *P* to every of those unequal parts in the Equinoctial, will divide the Plain into 12 unequal parts, through which last 12 unequal parts, and the Centre *Q*, if you draw right-lines, they shall be the true Hour-lines proper for the Plain.

And here by the way note, for that the Equinoctial Circle in this Scheme is a very oblique Arch, the Centre of it will be very remote, and the hour-spaces upon it (as also upon

the Plain) will be very close together in these small draughts, which is occasioned by the small Elevation that the South Pole hath above this Plain, *viz.* but 13 deg. 28 min. which you might find without drawing of the Scheme by Substrasting 25 deg. the Plains Reclination, represented in the Scheme by the line (or circle) N, Z, from Z, P, the Complement of the Latitude of the place. And therefore, foreseeing that the Pole hath but small Elevation above the Plain, and also what Pole, whether North or South that is Elevated. The better way will be to augment the Stile, and to draw the Dial according to these following directions.

How to draw the Hour-lines upon the Plain.

In the Scheme following, draw *First*, The right line W, Q, E, for the Horizontal, and Perpendicular thereunto, the line S, Q, R, for the Meridian and Hour-line of 12. which extend above the Horizontal-line, as to S.

Secondly, Upon S, as a Centre, with 60 deg. of your Chord, describe a small Arch of a Circle, and upon it set 13 deg. 28 min. the height of the Pole above the Plain, from A to B, and draw the line S, B, for the Stile.

Thirdly, At any convenient distance, answerable to the largeness of your Plain, draw a line parallel to W, E, as the line C, D, F.

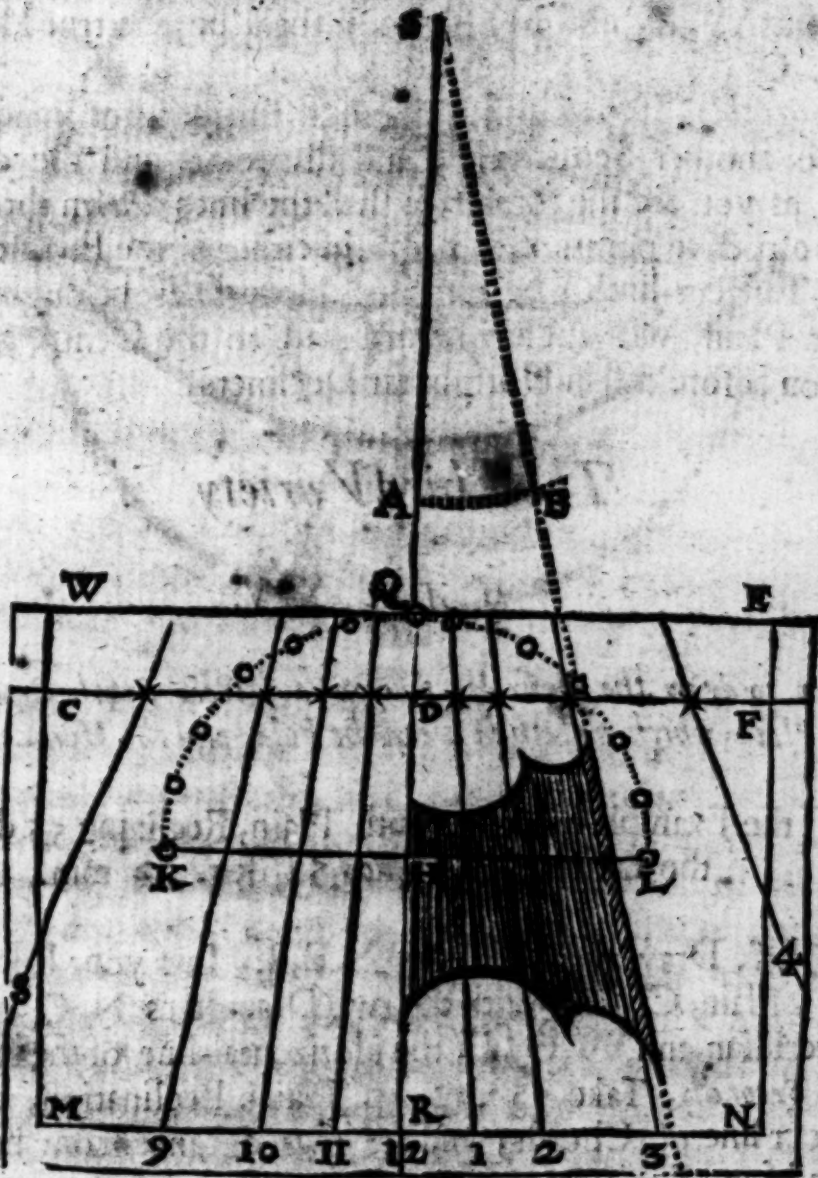
Fourthly, Set one Foot of your Compasses in D, and with the other foot, take the nearest distance to the Stile S, B, which distance set upon the Meridian from D to H.

Fifthly, Upon the point H, your Compasses opened to 60 deg. of your line of Chords. describe the Semicircle K, Q, L, which divide into 12 equal parts, in the points
 ○○○, &c.

Sixthly,

Geometrical Dialling.

South Reclining 25 degrees.



Sixthly, Lay a Ruler unto H, and upon every of the points $\odot \odot \odot$, &c. and it shall cut the Equinoctial line C, D, F, in the points $***$, &c. through which the Hour-lines

lines must pass : Wherefore, from the Centre S, and through the several points x, x, x, &c. in the line C, D, F, you draw straight lines, bounding them between any two lines, as W, E, and M, N, they shall be the true Hour-lines. Or,

Seventhly, If you draw another Tangent-line, and describe another Semicircle, and divide it, and the other line, as you did the former, so shall the lines drawn through the respective points x, x, x, &c. in either of the Equinoctial (or Tangent-lines) be the true Hour-lines belonging to your Plain, without any regard had to the Centre at all, as you before did in Upright far Decliners.

The Third Variety.

C H A P. XIV.

How to draw the Hour-lines upon a Direct South Reclining Plain, which passeth between the Pole, and the Horizon.

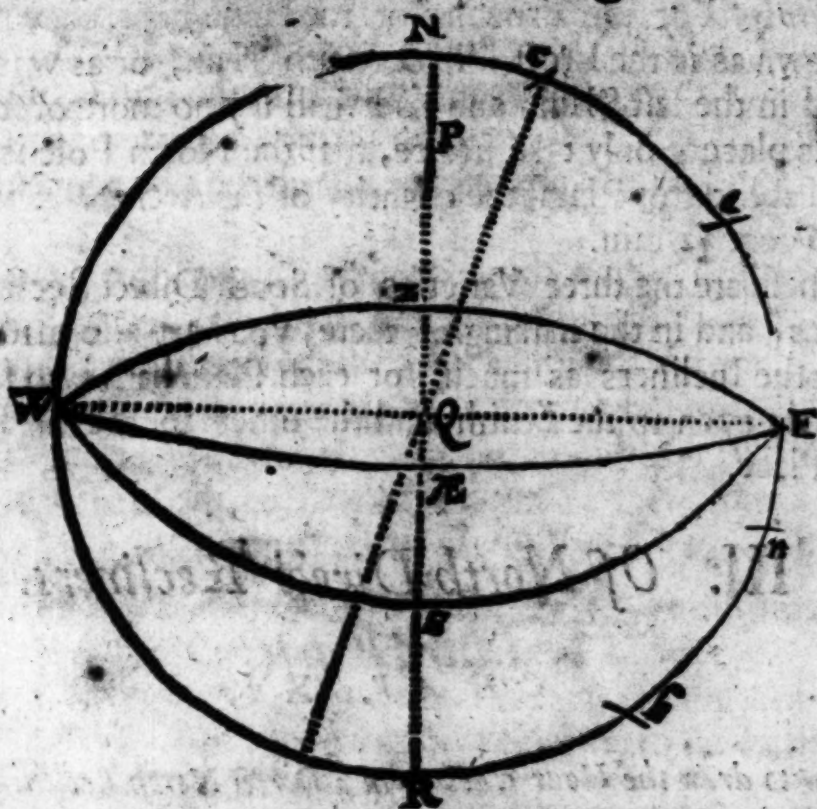
Let the Example be of a South Plain, Reclining 55 deg. in the Latitude of *London* 51 deg. 32 min.

F*irst*, Draw the Circle W, N, E, R. For your Reclining Plain, Cross it with the two Diameters N, Q, R, the Meridian, and W, Q, E, the Horizontal-line of the Plain.

Secondly, Take 55 deg. the Plains Reclination, out of your line of Chords, and set that distance from N to a, and from E to b.

Thirdly, Lay a Ruler from W to a, it will cut the Meridian in Z, so is Z the Zenith of the place, through which, and the points W and E, draw the Prime Vertical Circle W, Z, E.

Thirdly.



Thirdly, Lay a Ruler from W to *b*, and it will cut the Meridian in S, the South point of the Horizon, through which, and the points W and E, the Horizon of the Place W, S, E, must be drawn.

Fourthly, The Pole being distant from the Zenith of the place 38 deg. 28 min. equal to the Complement of the Latitude, set 38 deg. 28 min. from *a* to *c*, and a Ruler laid from W to *c*, shall cut the Meridian in P the Pole of the World, and 90 deg. of your line of Chords, being set from *c* to *n*, and a Ruler laid from W to *n*, shall cut the Meridian in AE, through which, and the Points W and E, must the Equinoctial Circle be described: The Centre whereof, as also of the Horizon, and Prime Vertical Circles, are all in the Meridian N, Q, R, extended where need requires, and how these Centres are to be found, is shewed already.

Fifthly, For the drawing of the Hour-lines, they must be drawn as in the Erect Direct South Plain, or as was directed in the last Plain, and so I shall say no more of them in this place; only take notice, that the North Pole is elevated above this Plain, the quantity of the Arch N, c. which is 16 deg. 32 min.

These are the three Varieties of South Direct Reclining Plains, and in the making of these, you have also made the opposite Incliners as much, for each Plain hath two faces, the one open to the Zenith, and the other to the Nadir of the Place.

III. Of North Direct Recliners.

C H A P. XV.

How to draw the Hour-lines upon a Direct North Reclining Inclining Plain.

AS in South Reclining Plains there were three Varieties, so also are there, as many in the North Recliners, For,

1. The North Plain may so Recline, that it may pass through the Meridian, just at the intersection of the Meridian with the Equinoctial, the Plain it self lying in the Equinoctial Circle, and the Poles thereof in the Poles of the World, and so it is called a Polar Plain. Or
2. The Plain may so Recline, that it may cut the Meridian between the Zenith and the Equinoctial. Or
3. It may Recline so far, as to cut the Meridian between the Equinoctial and the Horizon.

Examples of these three Varieties of North Reclining Plains follow.

The First Variety.

C H A P. XVI.

How to draw the Hour-lines upon a Direct Polar Plain, which Reclineth just to the Equinoctial.

Example of a North Plain, Reclining 51 deg. 32 min. equal to the Latitude of the Place, viz. London.

First, Describe the Circle E, A, W, R, for your Plain, cross it with the Diameters A, Q, R, for the Meridian, and W, Q, E, for the Prime Vertical Circle.

Secondly, Set 51 deg. 32 min. the Reclination of the Plain, (which in this Example is also equal to the Latitude of the place) from A to a, and also from E to b.

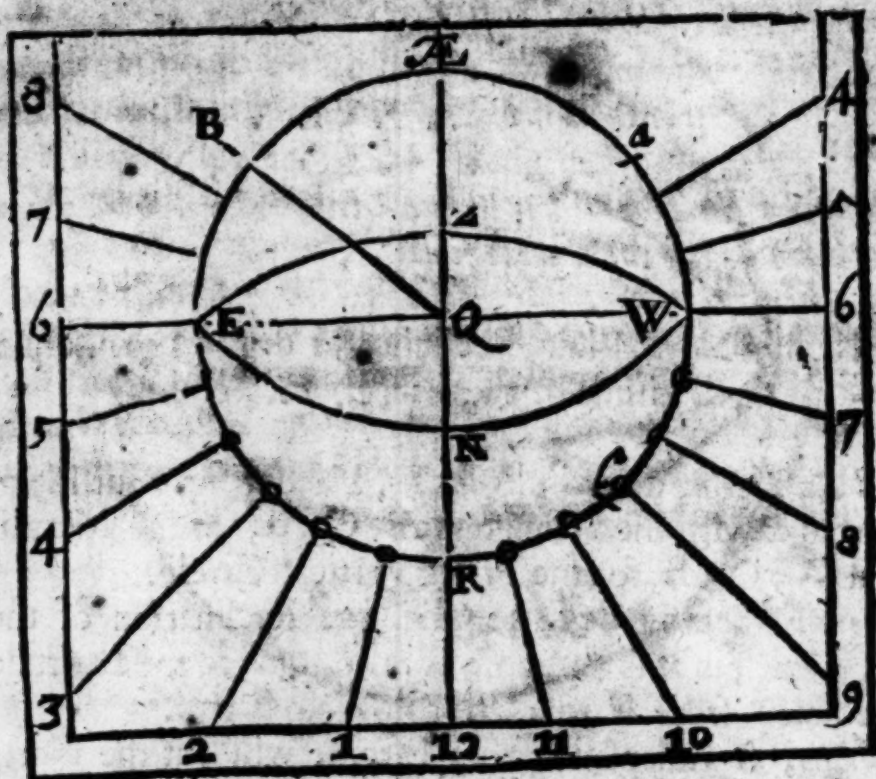
Thirdly, A Ruler laid from E to a, will cut the North part of the Meridian in Z, the Zenith of the place, and being laid from E to b, it will cut the Meridian in N, so is N the North point of the Horizon.

Fourthly, Through the Points W, Z, and E, (by former directions) draw the Prime Vertical Circle, or Azimuth of East or West, W, Z, E. And also through W, N, and E, draw the Horizontal Circle W, N, E.

Fifthly, Because the Pole of the World is always removed from the Zenith of the place, so much as is the Complement of the Latitude (in this Example 38 deg. 28 min.) Set 38 deg. 28 min. from a, (the point in the Plain, which found the Zenith point Z,) Northward of the Zenith, and the Compass point will fall in W, the West point of the Horizon; so that if a Ruler were laid from W to E, it would

Geometrical Dialling.

A Direct Polar Dial South.



would cut the Meridian in Q , for the Pole of the World, which is already the Centre of the Plain, so that the Pole of the World, and the Pole of the Plain fall both in one point, and the Pole Q is elevated above the Plain 90 deg. viz. the quantity of the Meridian line AE , Q , or rather the Arch AE , W , which is the measure thereof.

Sixthly, To draw the hours upon this Plain it is easiest of all others, for if you divide the Semicircle E , R , W , into 12 equal parts in the points $\odot \odot \odot$, &c. and through those Points draw straight lines from the Centre Q , they shall be the true Hour lines belonging to this Polar Plain.

And this Plain, by reason of its North Reclination, is, in Summer,

Summer, capable of receiving all the hours from Sun rising to Sun-setting, and therefore the hour-lines of 4 and 5 in the morning, and of 7 and 8 at night must be drawn through the Centre, as you did in the Vertical or Horizontal Dial, and as you see here done in this Figure.

The Stile of this Dial must be a streight Pin or Wyre, set perpendicular upon the Plain, from the Centre Q; and of any length. And this for the First Variety of North Recliners.

The South Inclining Plain opposite to this is directly the same, only the fore-noon hours in this must be the afternoon hours in that, and the hours of 4 and 5 in the morning, and of 7 and 8 in the evening must be omitted.

The Second Variety.

C H A P. XVII.

How to draw the Hour-lines upon a North Reclining Plain, which intersects the Meridian between the Zenith and the Equinoctial.

Let the Example be of a North Plain, Reclining 25 deg.

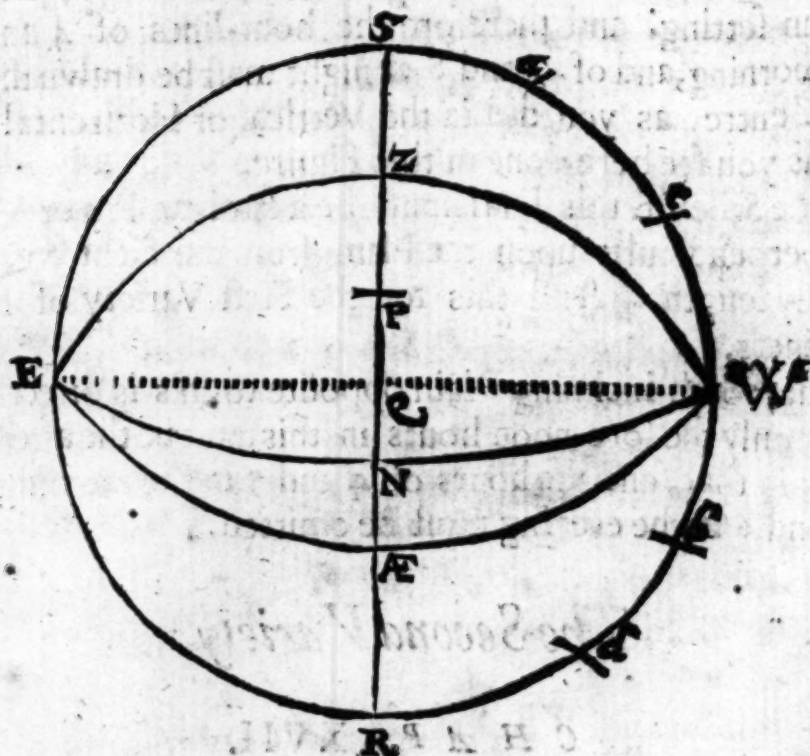
First, draw the Circle E, S, W, R, Representing your North Reclining Plain, and cross it with the two Diameters S, Q, R, the Meridian of the Place, and E, Q, W, the Horizontal-line of the Plain.

Secondly, Set the Reclination of the Plain 25 deg. from S to a, and from W to b.

Thirdly, Lay a Ruler from E to a, it will cut the Meridian in Z, the Zenith. And a Ruler laid from E to b, will

M

cu



cut the Meridian in N, the North point of the Horizon: so have you three points E, Z, and W, whereby to draw the Prime Vertical Circle, E, Z, W, and three points, also, viz. E, N, and W, whereby to draw the Horizon E, N, W.

Fourthly, Because the Equinoctial is always 90 deg. distant from either of the Poles, set 90 deg. upon your Plain, from *c* to *d*. Then laying a Ruler to E and *d*, it will cut the Meridian in *Æ*, so is *Æ* the point of the intersection of the Equinoctial, with the North part of the Meridian; wherefore through the points E, *Æ*, W, describe the Equinoctial Circle; the Centre whereof, as also of the Horizon, and Prime Vertical Circle, will fall in the Meridian S, Q, R, extended where need requires.

Fifthly,

Fifthly, The Horizon, Equinoctial, and Pole, being thus seated in their true positions, upon the Plain; the thing required in this Dial is, *The height of the Pole above the Plain*, which may be found in this manner. — Lay a Ruler from E to P, and it will cut the Plain in c, the distance S, c, measured upon your line of Chords, will contain 63 deg. 28 min. which is the height of the Pole above the Reclining Plain.

Lastly, For the drawing of the Hours, that is done the same way as in the Erect Direct South Plain, only here the Stile must be elevated above the Meridian-line 63 deg. 28 min. whereas there it was only 38 deg. 28 min. the complement of the Latitude. The North Pole is elevated above this Plain, and the hours that the Plain is capable to receive, are 4, 5, 6, 7, 8, and 9. in the morning, and 3, 4, 5, 6, 7, and 8, at night.

The Third Variety.

C H A P. XVIII.

How to draw the Hour-lines upon a Direct North Reclining Plain, which intersects the Meridian between the Equinoctial and the Horizon.

Let the Example be of a Direct North Plain, Reclining 79 deg. in the Latitude of London 51 deg. 32 min.

First, Draw the Circle E, S, W, R, representing your North Reclining Plain, and cross it with the two Diameters S, Q, R, for the Meridian of the Place, and with E, Q, W, the Horizontal line of the Plain.

M 2

Secondly,

Secondly, Set the Reclination of the Plain 70 deg. from S to *a*, and from W to *b*.

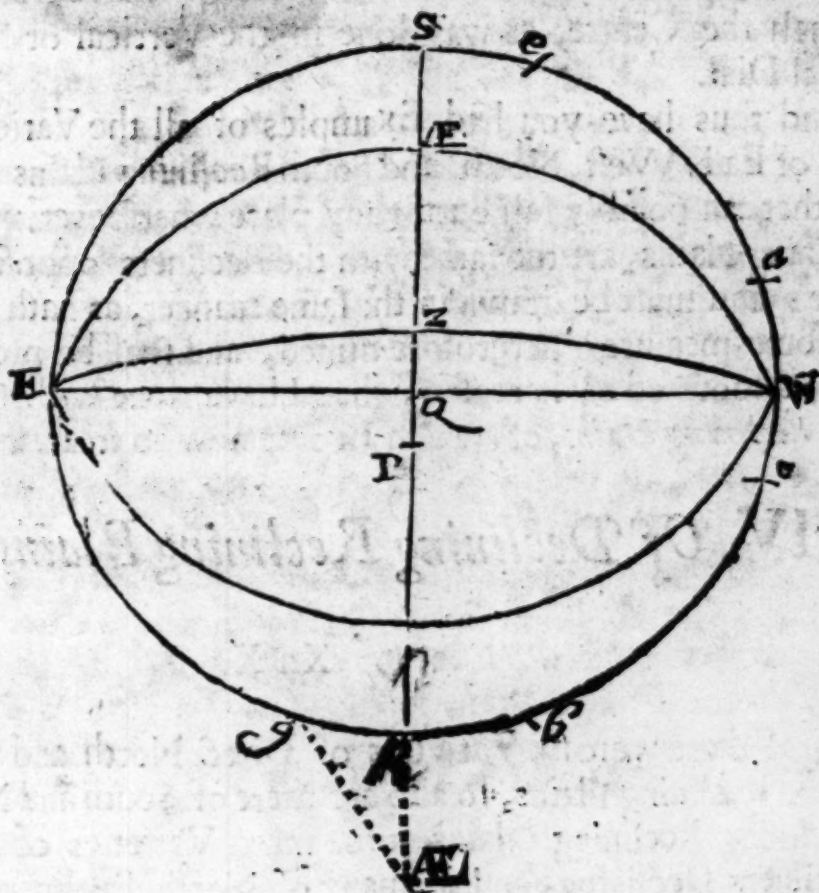
Thirdly, Lay a Ruler to E and *a*, it will cut the Meridian in Z the Zenith, through which and the points E and W, draw the Prime Vertical Circle E, Z, W. — Also, lay a Ruler from E to *b*, it will cut the Meridian in N, the intersection of the Meridian with the North part of the Horizon, and through this point, and E and W, describe the Horizon of the Place, E, N, W.

Fourthly, Forasmuch as the Pole is distant from the Zenith of the Place 38 deg. 28 min. (equal to the complement of the Latitude) set 38 deg. 28 min. from *a*, the point which gave the Pole P to *c*, and lay a Ruler from E to *c*, so shall it cross the Meridian in P, the Pole of the World.

Fifthly, Because the Equinoctial is in all places situate 90 deg. from either Pole. Take 90 deg. in your Compasses, and set them off from *c*, (the point which gave the Pole P,) both ways, to *e* above, and to *g* below. So a Ruler laid from E to *g*, will cut the Meridian (it being extended) in *Æ*, without the Plain, which shews that the North part of the Equinoctial Circle lies below this Plain. Therefore, lay a Ruler from E to *e*, and it will cross the Meridian in *Æ* above, within the Plain. So is *Æ* the point where the Meridian, and the South point of the Equinoctial will intersect, and through that point, and the points E and W, must the Equinoctial E, *Æ*, W, be drawn.

Sixthly, The Horizon, Pole, and Equinoctial, being thus projected, the thing required in this Plain is, *The height of the Pole above it, viz.* P, R, which may be found in this manner. — Lay a Ruler from E to P, and it will cut the Plain in *c*, the distance from R to *c*, measured upon the Chord, will be 71 deg. 32 min. which is the height of the Pole above this Reclining Plain.

Lastly,



Lastly, For the drawing of the Hour-lines, they are done in all respects as those before in South Erect Plains, only in this make the Elevation of the Stile 71 deg. 32 min. as you find it by your projection.

Your Hour-lines being drawn, erect the Stile 71 deg. 32 min. above the Meridian or Substile, letting it point up to the North Pole, because that Pole above this Plain is so much elevated, and being this Plain is but 20 deg. raised above the Horizon, viz. the complement of its Reclination, the Plain is capable to receive all the hours from 4 in the morning, to 8 at night, and therefore the hours of 4 and 5 in

the morning, and 7 and 8 in the evening, must be drawn through the Centre, as was done in the Vertical or Horizontal Dial.

And thus have you had Examples of all the Varieties, both of East, West, North, and South Reclining Plains; and no other can possibly fall out in any place whatsoever. The Inclining Plains, are the same with the Recliners opposite to them; and must be drawn in the same manner, as hath been (in some measure) heretofore hinted, and shall be more at large discoursed of hereafter, when I have done with *Declining Reclining Plains*, of which I come now to treat.

IV. Of Declining Reclining Plains.

C H A P. XIX.

AS there were six Varieties of Direct North and South Reclining Plains, so also are there of South and North Declining Reclining Plains, viz. three Varieties of South Recliners Declining, and as many of North Recliners Declining. For, in South Recliners Declining:

1. The Declination may be such, that the South Reclining Plain, may cut or fall upon the Meridian, just upon the Pole Point; and such Reclining Declining Plains, are called *Equinoctial Decliners*: Or,
2. The Declination may be such, that the Reclining Plain shall intersect the Meridian between the Zenith of the Place, and the Pole of the World: Or,
3. The Declination may be such, that the Reclining Plain shall cross the Meridian between the Pole and the Horizon.

These

*These are the three Varieties of South Recliners Declining.—
In North Recliners Declining there are three other Varieties. For,*

1. The Declination may be such, that the North Reclining Plain may cross the Meridian in the point where the Equinoctial intersects the Meridian, and then such Plains are called *Polar Declining Plains*, because the Poles of them lye in the *Axis* of the *World*, and the Substile in such Plains, will be always perpendicular to the Meridian of the place. Or,

2. The Declination may be such, that the Reclining Plain may intersect the Meridian, between the Zenith and the Equinoctial. Or,

3. The Declination may cause, that the Reclining Plain may fall upon the Meridian, between the Equinoctial and the Horizon.

Examples of all these Varieties follow.

L. Of

I. Of South Recliners.

The First Variety.

C H A P. XX.

How to draw the Hour-lines upon a South Reclining Declining Plain, which cutteth the Meridian in the Pole Point.

IN Declining Reclining Dials, before the Hour-lines can be drawn, three things must be given, and four things found, the things given are

- Data* { 1. The Latitude of the Place.
2. The Declination of the Plain.
3. The Plains Reclination.

The things required are,

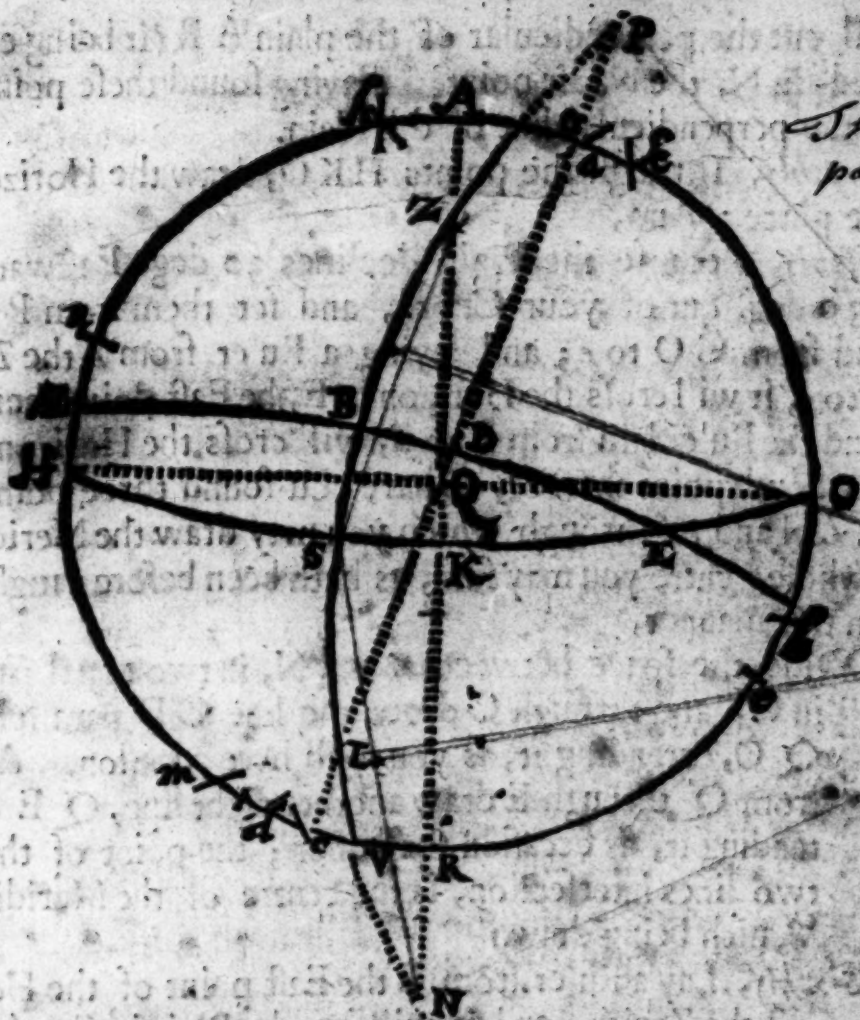
- Quas.* { 1. The distance of the Meridian and Horizon.
2. The height of the Pole above the Plain.
3. The distance of the Substile and Meridian.
4. The Plains difference of Longitude.

Let the Example be of a South Plain Declining East, 30 deg. and Reclining 34 deg. 32. min. in the Latitude of London, 51 deg. 32 min.

First, Draw the Circle H, A, O, R, and cross it with the two Diameters H, O, the Horizontal-line of the Plain, and A, Q, R, the perpendicular-line of the Plain, crossing each other at right-angles, in Q the Centre of the Plain.

Secondly,

This lot belong
page 95 ———



Secondly, Because the Plain Reclined 34° deg. $34'$ min. Take 34° deg. $34'$ min. from your line of Chords, and set them upon your Plain from A to *a*, from H to *b*, and from R to *c*.

Thirdly, Lay a Ruler from \hat{Q} to a , and it will cut the perpendicular line of the Plain in Z , the Zenith of the place. Also a Ruler laid from \hat{O} to b , will cut the Plains perpendicular, in K , the intersection of the Horizon of the place, with the Plains perpendicular. And a Ruler laid from \hat{Q} to

c, will cut the perpendicular of the plain *A R* (it being extended) in *N*, the Nadir point. Having found these points upon the perpendicular line of the Plain.

Fourthly, Through the points *H K O*, draw the Horizon of the place; And,

Fifthly, Because the Plain declines 30 deg. Eastward, take 30 deg. out of your Chord, and set them from *R* to *d*, and from *O* to *e*; and laying a Ruler from *Z* the Zenith to *e*, it will cross the Horizon in *E*, the East point thereof, and the Ruler laid from *Z* to *d*, will cross the Horizon in *S*, the South point thereof, so have you found three points, viz. *Z N* and *S*, through which you may draw the Meridian, whose Centre you may find, as hath been before taught: or in this manner,

Divide the space between *Z* and *N*, in two equal parts in *C*, and through *C* draw the line *C D* parallel to *Q O*, extending it, as you shall have occasion. Also from *Q* through *E* draw another right line, *Q E* extending it, as occasion shall offer; the point of those two lines intersection, is the centre of the Meridian. Which being drawn

Sixthly, Lay a Ruler from *E* the East point of the Horizon, to *Z* the Zenith, and it will cut the Plain in *h*. And, because the Pole of the World is distant from the Zenith 38 deg. 28 min. equal to the Complement of the latitude, set 38 deg. 28 min. from *h* upon the Plain. and it will fall just upon *P*, which is the point of the Plains intersection with the Meridian. which demonstrates the Pole to have no Elevation above the Plain, and so the Plain to be *Equinoctial declining*.

Seventhly, Draw the line *P Q L* for the Axis of the World, and, because the Equinoctial Circle is, in all parts, distant from either Pole 90 deg. set 90 deg. from *P*, or *L*,

to \mathcal{E} ; and through Q draw the line $\mathcal{E} Q \mathcal{E}$ for the Equinoctial Circle, which is here a straight line, and being extended, would pass through the Centre of the Meridian, and also through the East and West points of the Horizon, as it ought to do.

The Scheme being thus projected, the four requisites from it are easily obtained, For

1. To find the distance of the Meridian, and the Horizon $O P$. The Arch $O P$ measured upon your line of Chords will contain 71 deg. 53 min. the distance required.
2. The height of the Pole above the Plain (the point P) 00 deg. 00 min. therefore it is an Equinoctial Declining Plain.
3. The distance of the Substile and the Meridian, the point P also. Therefore that, as also, all the hours must be Parallel to the Substile.
4. To find the Plains difference of Longitude, $Q P B$. Lay a Ruler from P to B , and it will cut the Plain in m , the distance $L m$, measured upon your Chord, is the Plains difference of Longitude 24 deg. 19 min.

These Requisites being thus found, I will now shew.

How the hour-lines are to be drawn upon the Plain.

First, Draw a line as $B A C$ for the horizontal line of your Plain, and upon any convenient point therein, as upon A , with 60 deg. or the Radius of your line of Chords, describe the Semicircle $B D C$.

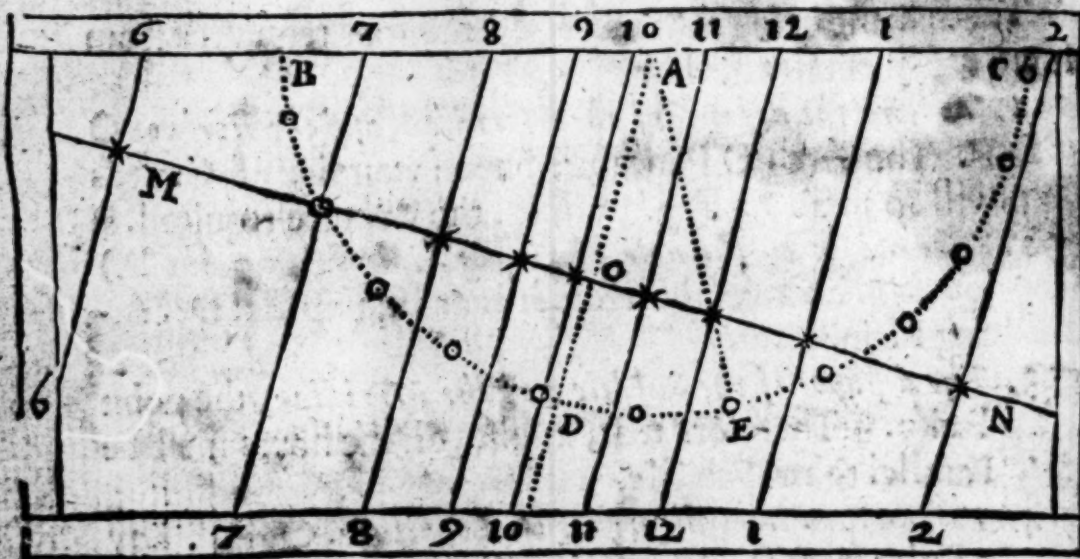
Secondly, From your line of Chords take 71 deg. 53 min. the distance of the Meridian and Horizon, and set them from B to D , and draw the line $A D$ for the Substile.

Thirdly, Take 24 deg. 19 min. the Plains difference of Longitude, and set that distance from D to E , and draw the line $A E$.

N 2

Fourthly,

*A South Plain Declining East 30 deg. Re-
clining 34 deg. 32 min.*



Fourthly, Divide the Semicircle B D C into 12 equal parts, at the points $\odot \odot \odot$, &c. beginning the division at the point E.

Fifthly, Through the Point O, (or any other point taken at all adventures in the Substilar line) draw a line M O N at right angles (or perpendicular) to the Substilar, representing the Equinoctial.

Sixthly, Lay a Ruler from A, and every of the points $\odot \odot \odot$, &c. in the Semicircle, and it will cross the Equinoctial line in the Points x x x, &c.

Lastly, If through these points x x x, &c. you draw right lines, parallel to the Substilar, they shall be the true hour-lines belonging to your Plain, the hour line of 12 being that where you began to divide your Semicircle, that is, at the mark (or *) which was made from the point E.

For

For the Stile of this Dial, it may be either a straight Pin or Wire, of the just length of the line A O, erected perpendicularly upon some point of the Substile (as at A or O) the very top of the shadow thereof giving the hour among the hour-lines upon the Dial.

Or else the Stile may be a Plate of Brass or Iron, of the breadth of A O, set perpendicular to the Plain; upon the Substilar line A O D, the shadow of whose upper edge shall give the true hour of the day.

The Second Variety.

C H A P. XXI.

How to draw the Hour-lines upon a South Reclining Plain, Declining East or West, which passeth between the Zenith and the Pole.

IN this, as in all other Decliners Reclining, three things must be known, and four must be found, before the drawing of the hour-lines.

Let the Example be of a South Reclining Plain, Declining East 30 deg. and Reclining 20 deg. in the Latitude of 51 deg 32 min. London.

<i>Data</i>	1. Latitude of the Place	51	32
	2. Declination South East	30	00
	3. Reclining south.	20	00

Quæsitæ

- Questia* § 1. The distance of the Meridian and Horizon.
 § 2. The height of the Pole above the Plain.
 § 3. The distance of the subtile and the Meridian.
 § 4. The Plains difference of Longitude.

First, Describe the Circle $H A O R$, representing your Reclining Declining Plain, and cross it at right Angles, with the two Diameters $A R$, for the Perpendicular, and $H O$, for the Horizontal-line of the Plain.

Secondly, Take 20 deg. the Plains Reclination, out of your Chord, and set them from A to a , from O to b , and from R to c .

Thirdly, A Ruler laid from H to a , will give you Z , the Zenith, and laid from H to b , will give you K , the intersection of the Horizon, with the Perpendicular-line of the Plain. And the Ruler laid from H to c , will give you N the Nadir, then through the Points $H K$ and O , draw the Horizon $H K O$.

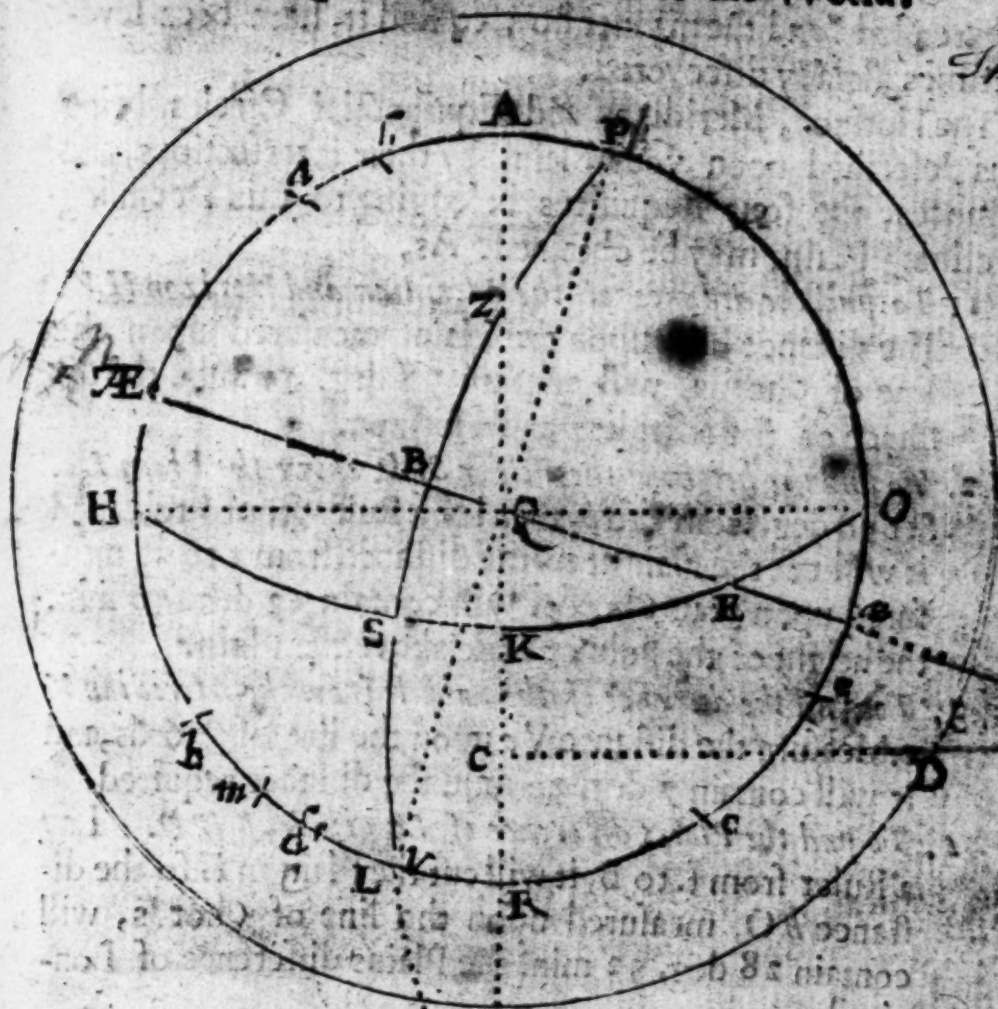
Fourthly, Take 30 deg. the Plains Declination, out of your line of Chords, and set them from R to d Westward, (because the Plain Declines Eastward) and also from O to e . So a Ruler being laid from Z to e , shall cut the Horizon in E , the East point thereof, and laid from Z to d , shall cut the Horizon in S , the South Point thereof. Thus have you three points $Z S$ and N , through which to draw the Meridian Circle, which you may extend without the Plain to P and N , occasion sometimes requiring it should be so.

Fifthly, Forasmuch as the Pole of the World is always distant from the Zenith, equal to the Complement of the Latitude of the place, as here at London 38 deg. 28 min. Lay a Ruler from E to Z , and it will cut the Plain in h , from whence set 38 deg. 28 min. to k . So a Ruler laid from E to k , will cut the Meridian (extended) in the point P , the North Pole of the World. And a Ruler laid from P through

through Q, shall cross the Meridian in L, the South Pole
and the line P Q L shall be the Axis of the World.

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019 7.



Sixthly, Take 90 deg. off your Chord, and set them
from the point, which found the Pole at P to S. So a Ru-
ler laid from E to S, shall cut the Meridian in B, through
which

which point, and through the point E, the Equinoctial Circle must be described, whose Centre will be in the Axes P L extended, and the manner how to find it, hath been several times already discovered.

The Horizon, Meridian, and Equinoctial Circles being thus described upon your Plain, by their intersections, and distances, the four Requisites, belonging to this Declining Reclining Plain, may be obtained. As,

1. To find the distance of the Meridian and Horizon H V.

The distance H upon the Plain, measured upon the line of Chords, will contain 78 deg. 50 min. the distance of the Meridian and Horizon.

2. To find the height of the Pole or Style above the Plain L c.

Set 90 deg. from c to b, then lay a Ruler from b to L, and it will cut the Plain at m, the distance from c to m, measured upon your Chords, will contain 13 deg. 40 min. the height of the Pole or Style above the Plain.

3. To find the distance of the Substile from the Meridian V c.

Measure the distance V c upon the line of Chords, and it will contain 7 deg. 30 min. the distance required.

4. To find the Plains difference of Longitude, B L D. Lay a Ruler from L to B, it will cut the Plain in k, so the distance b O, measured upon the line of Chords, will contain 28 deg. 52 min. the Plains difference of Longitude.

Thus are the four Requisites belonging to this Plain found, and in this Example two things are very observable.

1. Whereas P, the North Pole of the World, falls without the Plain, and the Point L, representing the South Pole, falls within the Plain, it denotes, that the South Pole must be elevated.

2. In respect that the line or arch L c, which is the height of the Style or Pole above the Plain, is but of small

Quan-

Quantity, viz. 13 deg. 40. min. it will from thence follow, that the Equinoctials Centre will be very remote, and that the hour-lines near to the Substile will be very close, so that in small Dials their distances one from another will be insensible; and therefore you may save the labour of describing the Equinoctial Circle, and be satisfied in finding of the point B, by which the Plains difference of Longitude is found — For, in such cases as this, the Plains difference of Longitude, the distance of the Meridian from the Horizon, and of the Substile distance from the Meridian, and the height of the Pole above the Plain being gained; you may proceed to draw the Dial as followeth, not much differing from the drawing of the Upright far Declining Dial Chapter.

How to draw the Hour-lines upon the Plain.

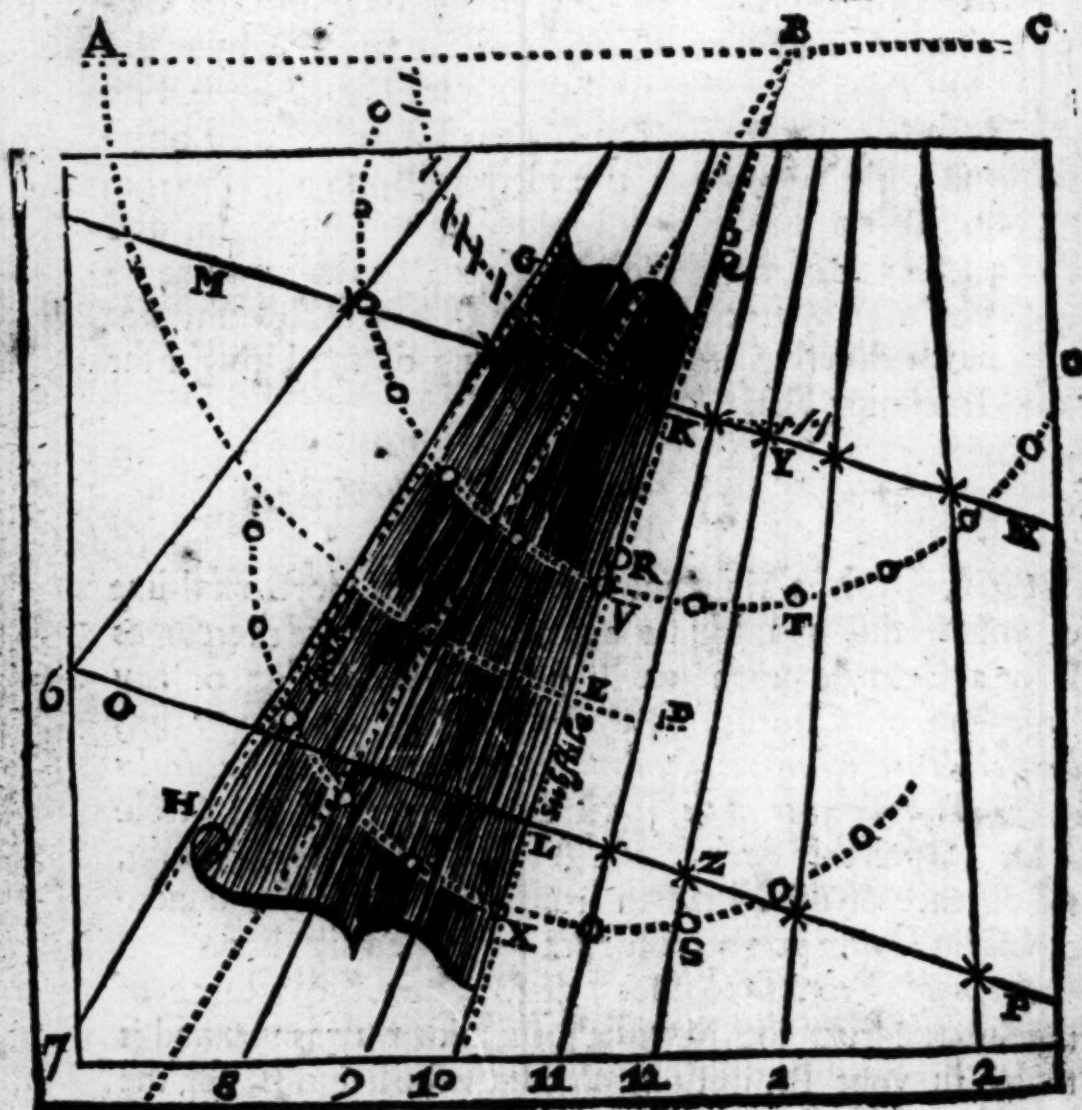
First, Draw a right line A B C, for the Horizontal-line of your Plain, and assume any convenient place therein, as B for a Centre; upon which point, with 60 deg. of any large line of Chords, [For it is necessary, not only in this, but for divers other occasions, to have several lines or scales of Chords upon your Ruler] describe the arch of the Circle A D. Upon this Arch, from A to D, set 73 deg. 50 min. the distance of the Meridian from the Horizon, and note the point D, but you need not draw the Meridian line.

Secondly, From D to E set 7 deg. 30 min. the distance of the Substile from the Meridian, the same way as you find it to lye in your Projection; and draw the line B E, for the Substile. Also, upon the same Arch, set off 13 deg. 40 min. the height of the Stile, from E to F, and draw the line B F for the Stile. Which being but of small elevation, viz.

O

deg.

South Declining East 30 deg: Reclin-
ing 20 deg.



13 deg. 40 min. ought to be augmented ; and therefore (at any convenient distance (futable to the bigness of your Dial plain) draw a line, as G H, parallel to B F, for your augmented Stile or Axis.

Thirdly, Through any two points, taken at adventure, in the Substilar line, as K and L, draw two right lines perpendicular, or at Right Angles to the Substilar, as the lines M K N, and O L P. Then from the point K, take the least distance to the Substilar G H, and set that distance upon the Substilar from K to Q. Also from the point L, take the nearest distance to the augmented Stile G H, and set the distance upon the Substilar from L to R.

Fourthly, Upon the points Q and R, as upon two Centres, with 60 deg. of any of your Chords, describe two Semicircles (or other Portions of Circles) and in either of them, set 28 deg. 12 min. from V to T upon one of them, and from X to S upon the other.

Fifthly, Lay a Ruler from Q to T, and it will cut the Tangent line in Y; Also lay a Ruler from R to S, it will cut the other Tangent line in Z, and a right line drawn through the points Y and Z, shall be the hour-line of 12.

Sixthly, At the points S and T, begin to divide the several Semicircles into 12 equal parts or hours, by taking 15 deg. of your Chord, and setting them from S and T both ways, at the points $\odot \odot \odot$, &c. so many times as the Plain will receive hour-lines.

Seventhly, Lay a Ruler from the points Q and R, to every of the points $\odot \odot \odot$, &c. in their respective Semicircles, and it will cross their several Tangent-lines in the points x x x, &c.

Lastly, Through the points x x x, in both the Tangent-lines, draw right lines, each to his correspondent, which the hour-line of 12 will direct you how to do, and

These shall be the true hour-lines of your Plain.

For the Stile of this Dial, it may be either of Wire or Plate, containing an Angle equal to the height of the Pole above the Plain, but it must be augmented answerable to the augmented Stile, as you see in the Figure, and must be set in its proper place upon the Substilar-line, and also perpendicular, or square to the Plain, and so is this Dial finished.

The Third Variety.

C H A P. XXII.

How to draw the hour-lines upon a South-reclining Plain, Declining East or West, which intersects the Meridian between the Pole and the Horizon.

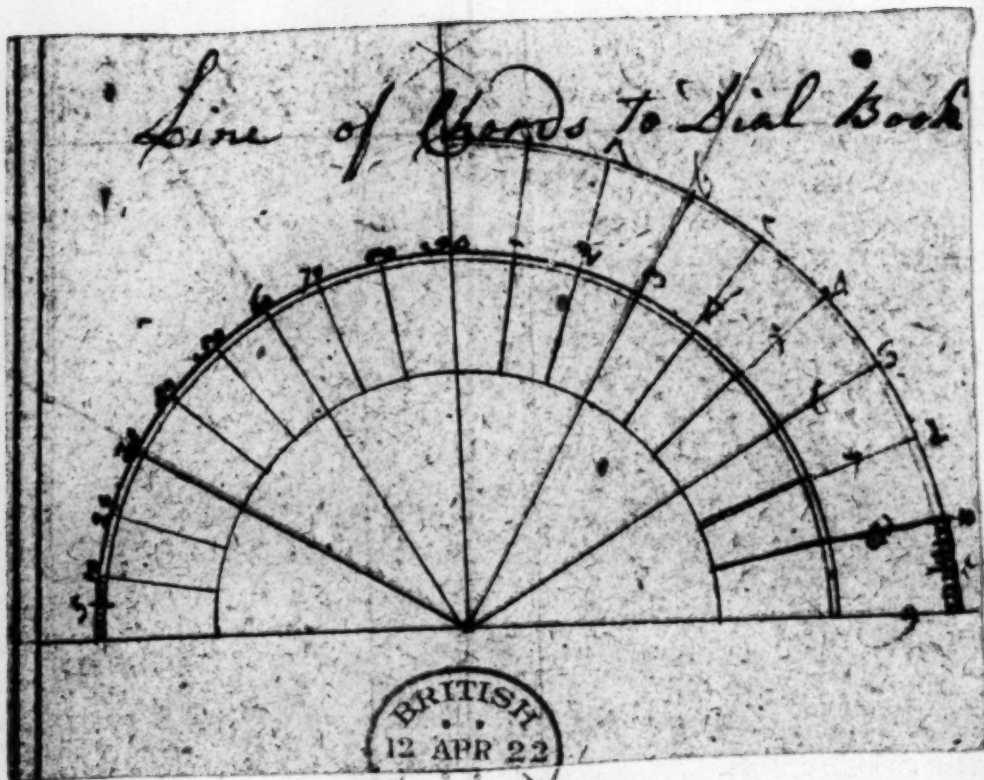
Let the Example for this third and last Variety, of South Declining Reclining Plains, be of a South Plain, Declining Eastward 30 deg. and Reclining 55 deg. In the latitude of 51 deg. 32 min. London.

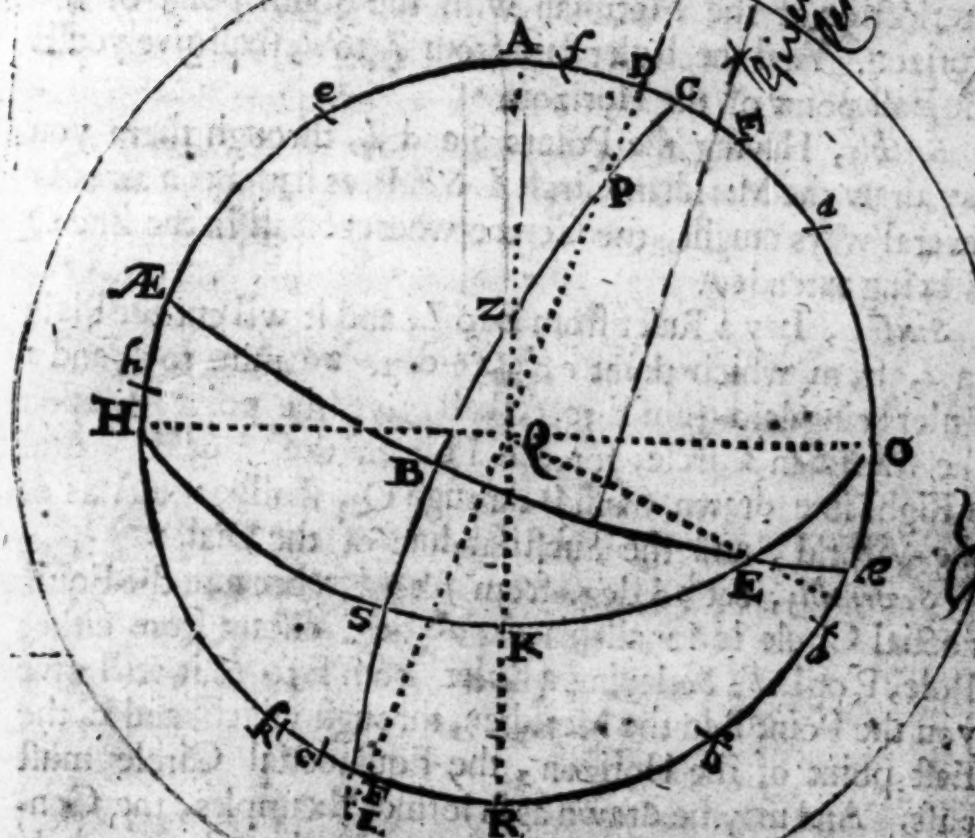
		deg.	min.
Data	The Latitude of the Place	51	32
	The Declination Eastward	30	00
	The Reclination	55	00

The distance of the Meridian from the Horizon.
 The height of the Pole or Stile above the Plain.
 The Substiles distance from the Meridian.
 The Plains Difference of Longitude.

First,

Line of Hours to Dial Book





This for finding of Reclination

of Dial in Page 100

First, Draw the Circle AHRO, for your Reclining Declining Plain, and cross it with the two diameters AR the Vertical, and HO the Horizontal-line of the Plain.

Secondly, Set 55 deg. the Plains Reclination, from A to a, and from O to b.

Thirdly, Lay a Ruler from H to a, and it will give you Z, the Zenith, and laid from H to b, it will give you K, the point of the Horizons intersection with the Plains Vertical-line. So have you three points HK and O, through which to describe the Horizon of the place HKO.

Fourthly, Set 30 deg. the Plains Declination, from R to c Westward, (because the Plain declines Eastward) and from O to d. So a Ruler laid from Z to c, shall give you S, the inter-

intersection of the Meridian with the South point of the Horizon. And the Ruler laid from Z to *d*, shall give you E the East point of the Horizon.

Fifthly, Having the Points S and Z, through them you may draw the Meridian Circle L S Z P, as hath been already several ways taught, the Centre whereof fall in the line Q E being extended.

Sixthly, Lay a Ruler from E to Z, and it will cut the Plain in *e*, from which point *e* set 38 deg. 28 min. to *f*, and a Ruler being laid from E to *f*, shall give the point P, upon the Meridian Circle, for the Pole of the World. And a Right line drawn from P through Q, shall be the Axis of the World, and the Substilar-line of the Dial.

Seventhly, Set 90 deg. from *f* to *h*, (because the Equinoctial Circle is in all places, 90 deg. distant from either Pole, P or L.) So laying a Ruler from E to *h*, it will give you the Point B in the Meridian, through which, and E, the East point of the Horizon, the Equinoctial Circle must pass. And may be drawn as in former Examples, the Centre thereof being in the Axis of the World, P L extended.

These three principal Circles, viz. the Horizon, Meridian, and Equinoctial being described, according to their true Situations upon the Plain, the same fore-mentioned Requisites may from thence be easily deduced, as followeth.

1. To find the distance of the Meridian from the Horizon O C. The Arch O C, measured upon the line of Chords, will contain 64 deg. 41 min. the Substile's distance from the Meridian.
2. To find the height of the Pole or Stile above the Plain P D. Set 90 deg. from D to *e*, and lay a Ruler from *e* to P, it will cut the Plain in *m*, the Arch D measured will contain 19 deg. 25 min. the height of the Stile.
3. To find the Substile's distance from the Meridian C D.

This

This Arch measured will contain 6 deg. 2 min. the distance of the Substile from the Meridian.

4. *The Plains difference of Longitude B P Q.* A Ruler laid from P to B, will cut the Plain in *k*. So the distance *F k* measured, will be 17 deg. 38 min. the Plains difference of Longitude.

These Requisites being thus found, you may proceed to draw the hour-lines in this as in other Plains. First, by laying a Ruler upon P, the Pole of the World, to B, the intersection of the Meridian and Equinoctial, which will cut the Plain in *k*, at which point begin to divide the Semicircle into 12 equal parts. And from Q, to each of them, lay a Ruler crossing the Equinoctial Circle, and dividing that into 12 unequal parts, to which unequal parts of the Equinoctial, a Ruler laid, it will divide the Plain into 12 other unequal parts, through which, and the Centre Q, right-lines being drawn, they shall be the true hour-lines proper to the Plain.

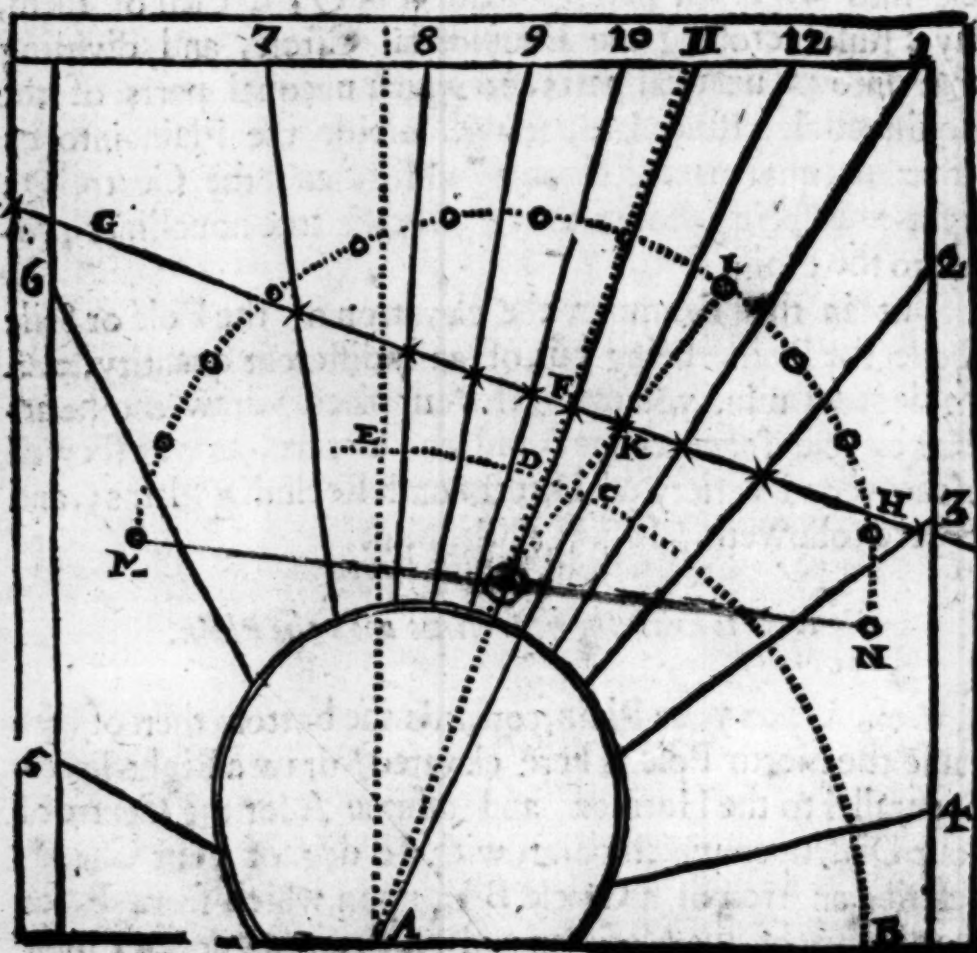
But in this Example, the elevation of the Pole or Stile above the Plain, being but of an indifferent quantity, viz. 19 deg. 25 min. you may (if you please) draw the hour-lines by one Tangent-line, and the Centre, as was shewed in the second Variety of Direct South Reclining Plains; and as here followeth.

How to draw the hour-lines upon the Plain.

First, Upon your Plain, towards the bottom thereof (because the North Pole is here elevated) draw a Right-line A B parallel to the Horizon, and assume A for the Centre of your Dial, upon which point, with 60 deg. of your Chord, describe an Arch of a Circle B E, upon which from B, set the distance of the Meridian and Horizon, 64 deg. 41 min.

to C, and draw the line A C for the hour-line of 12. Also, upon the same Arch, from C to D, set 6 deg. 2 min. the distance of the Substile from the Meridian; and draw the line A D for the Substilar. Again, upon the same Arch, set off 19 deg. 25 min. the height of the Stile, from D to E, and draw the line D E for the Axis of the Stile.

*A South Plain Declining Eastward 30 deg.
and Reclining 55 deg.*



Secondly,

Secondly, Upon any part of the Substilar-line, assume any point at pleasure. As F, through which draw the right-line G F H perpendicular to the Substile.

Thirdly, From the point F, take the greatest distance to the Axis of the Stile, and set that distance upon the Substilar-line from F to O, and upon the point O, with 60 deg. of your Chord, describe the Semicircle M L N.

Fourthly, Lay a Ruler from O to K (the point where the Tangent (or Equinoctial-line) crosseth the Meridian) and the Ruler will cut the Semicircle in L, at which point begin to divide it into 12 equal parts in the points O O O, &c.

Fifthly, Lay a Ruler from O, the Centre of the Semicircle, to the several points O O O in the Semicircle, and the Ruler will cut the Tangent-line in the points x x x, &c.

Lastly, If from the Centre A, through these points x x x, &c. you draw right-lines, they shall be the proper hour-lines belonging to your Plain.

For the Stile, it may be either of Plate or Wyre, elevated above the Substile, to an Angle of 19 deg. 25 min. and set up perpendicularly upon the Substilar, as in all other Dials. And thus have I done with all the Varieties of South Declining Reclining Plains.

II. Of North Recliners.

The First Variety.

C H A P. XXIII.

How to draw the hour-lines upon a North-Reclining Plain, Declining East or West, which cutteth the Meridian, at the intersection thereof with the Equinoctial.

Let the Example be of a North-plain, declining to the West 60 deg. and Reclining from the Zenith 32 deg. 11 min. in the Latitude of London 51 deg. 32 min.

		deg.	min.
Data	1. Latitude of the Place	51	32
	2. Declination of the Plain North West	60	00
	3. Reclining North	32	11

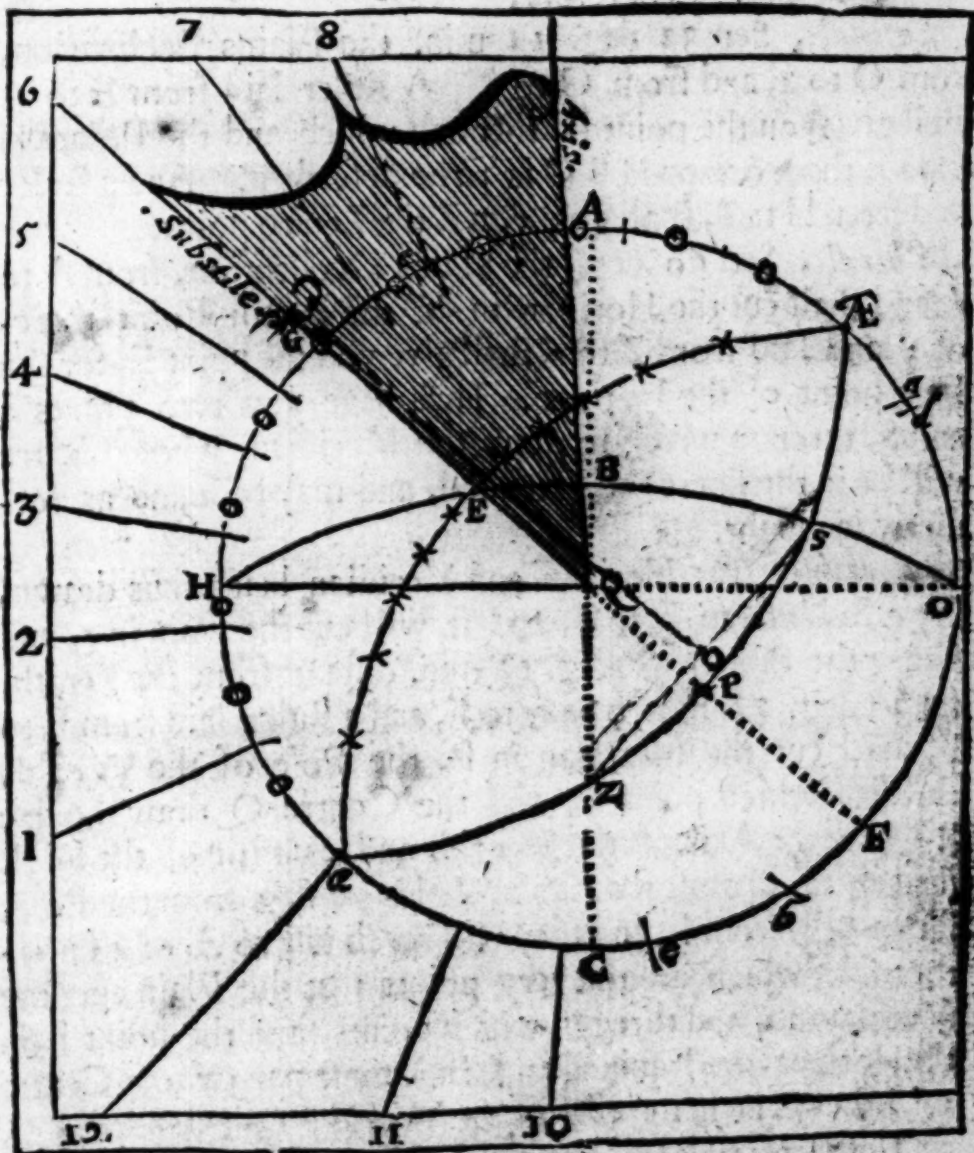
- Quesita* {
1. The distance of the Meridian and Horizon.
 2. The height of the Pole or Stile above the Plain.
 3. The distance of the Substile and the Meridian.
 4. The Plains difference of Longitude.

First, Describe the $AHC O$, for the Declining Reclining Plain; cross it at right Angles with the two Diameters HO for the Horizontal, and AC for the Vertical-line of the Plain.

And here for Variety more, than for necessity, in these three following Examples, North Recliners Declining, I will (in the several Schemes) place the Zenith and Pole

North } Declining West
Reclining

0 min.
60 00
32 11



$V = 13$

Pole downwards, because the Stile in all these Dia's must point upwards, the North Pole being always Elevated, and in so doing the Hour-lines Stile and Substile, will stand in the Scheme as they are to stand in the Dial. And the manner of work will be the same as before. Wherefore,

Secondly, Set 32 deg. 11 min. the Plains Reclination, from O to *a*, and from C to *b*. A Ruler laid from H to *a*, shall give you the point B, through which and the Points H and O, the Horizon H B O is to be described. And a Ruler laid from H to *b*, shall give you Z the Zenith point.

Thirdly, Set 60 deg. the Plains Declination, from A to *d*, and shall cut the Horizon in S, the South Point thereof; and laid from Z to *e*, shall give you the point E, for the East point of the Horizon. Thus have you two points Z and S, through which to draw the Meridian, whose Centre will be in the line Q E extended, and may be found as formerly is taught.

Fourthly, The Horizon and Meridian being thus drawn, lay a Ruler from E to Z, and it will cut the Plain in *c*, and seeing the Pole is 38 deg. 28 min. distant from the Zenith, set 38 deg. 28 min. from *c* to F, and a Ruler laid from E to F, will cut the Meridian in P, the Pole of the World, through which point P, and the Centre Q draw the line P Q for the Axis of the World, and Substile of the Dial. And again, because the Equinoctial is 90 deg. from the Pole, set 90 deg. from F, and they will reach just to A or *a* on either side, which are the very points that the Plain cuts the Meridian in, and through which points, and the point E, in the Horizon, the Equinoctial Circle must pass; whose Centre will always be in the Axis of the World P Q extended.

The Horizon, Meridian, and Equinoctial being thus drawn, you may find the four Requisites in this manner.

1. To find the distance of the Meridian from the Horizon Æ O . The Arch Æ O measured by your line of Chords, will be found to contain 47 deg. 18 min. which is the Substile distance from the Meridian.
2. To find the height of the Pole or Stile above the Plain, P F . A Ruler laid from a to P , will cut the Plain in O , so the distance F O 42 deg. 52 min. is the height of the Pole above the Plain.
3. The distance of the Substile from the Meridian $a G$, which measured is 90 deg.
4. The Plains difference of Longitude, G P a , or the Arch $a G$, as before 90 deg.

In this Scheme two things are remarkable,

1. The Plains cutting the Meridian in its intersection, with the Equinoctial, And
2. The Axis of the World passing through the East point of the Horizon, both which denote the Plain to be Polar Declining, and the Substile to be the same with the hour-line of 6. And the hour-line of 12 at Right-angles thereto, wherefore the hour-lines may be drawn as followeth.

To draw the hour-lines upon the Plain.

First, Lay a Ruler from P to Æ , where the Meridian and Equinoctial intersect, which is upon the Plain at the very point Æ , wherefore there begin to divide the Semicircle Æ G a into 12 equal parts at the points $\odot \odot \odot \&c.$

Secondly, Lay a Ruler to Q , and every of the points $\odot \odot \odot \&c.$ and it will cut the Equinoctial in the points, x x x dividing that into 12 unequal parts.

Thirdly, A Ruler laid to P , and the several points x x x in the Equinoctial, will cut the Plain in the marks $| | | \&c.$

Lastly,

Lastly, A Ruler laid from Q to the several marks | 1 |, &c. and straight lines drawn thereby, shall be the true hour-lines fitting this Polar Declining Plain,

For the Stile, it must be of Plate or Wire set upright upon the Substilar, to an Angle of 42 deg. 52 min. and must point upwards to the North Pole.

The Second Variety

C H A P. XXIV.

How to draw the hour-lines upon a North Reclining Plain, Declining East or West, the Plain passing through the Meridian, between the Zenith and the Aequinoctial.

IN this, (as in the former Examples) three things must be given, and four found before the hour-lines can be drawn.

		deg. min.
Data	1. Latitude of the Place	51 32
	2. The Declination of the Plain, North W.	60 00
	3. The Plains Reclination	16 00

Quesita	1. The distance of the Meridian from the Horizon
	2. The height of the Pole or Stile above the Plain.
	3. The Substiles distance from the Meridian.
	4. The Plains difference of Longitude.

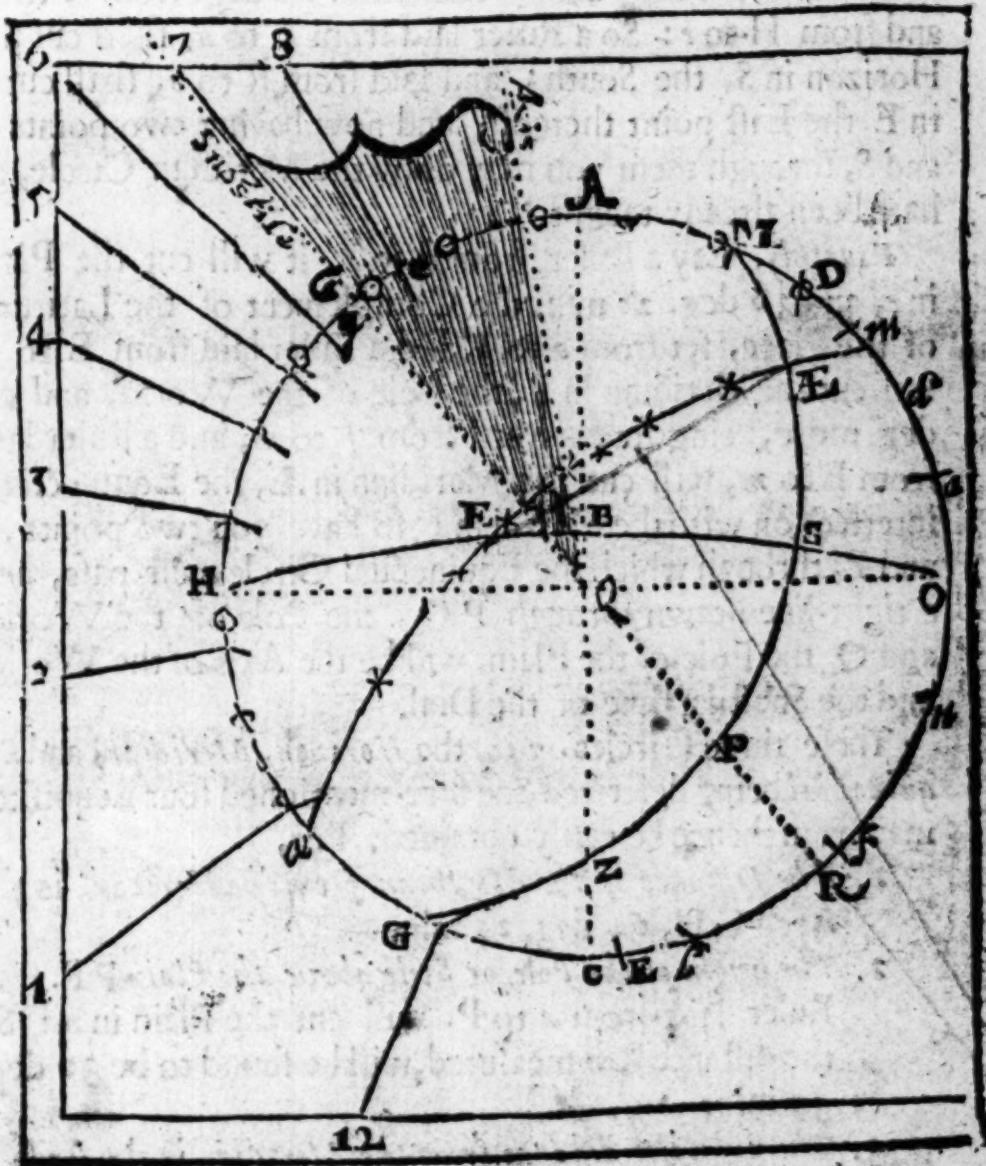
First, Describe the Circle A H C O for the Plain, and cross it with the Diameters A C, and H O, for the Horizontal and Vertical-lines thereof.

Secondly,

A North Dial } Declining West
Reclining

60
16

prove
This



to prove

Secondly,

Secondly, (As in the last Example.) set 16 deg. the Plains Reclination, from O to *a*, shall give the point B, through which and the points H and O, the Horizontal Circle H B O is to be described. Also a Ruler laid from H to *b*, shall find the Zenith Point of Z.

Thirdly, Set the Plains Declination 60 deg. from A to *d*, and from H to *e*: So a Ruler laid from Z to *d*, shall cut the Horizon in S, the South; and laid from R to *e*, shall cut it in E, the East point thereof; and now having two points Z and S, through them you may draw the Meridian Circle, as hath been already taught.

Fourthly, Lay a Ruler from E to Z, it will cut the Plain in *c*, and 38 deg. 28 min. the Complement of the Latitude of the Place, set from *c* to *f*, and a Ruler laid from E to *f*, will cut the Meridian in P, the Pole of the World, and 90 deg. more, being set forward from *f* to *m*, and a Ruler laid from E to *m*, will cut the Meridian in A, the Equinoctials intersection with the Meridian; so have you two points A and E, through which the Equinoctial Circle must pass, and a right-line drawn through P Q, the Pole of the World, and Q the Pole of the Plain, will be the Axis of the World, and the Substilar-line of the Dial.

These three Circles, *viz.* the *Horizon*, *Meridian*, and *Equinoctial* being described, the fore-mentioned four Requisites may from thence be easily obtained. For,

1. The Distance of the Meridian from the Horizon, is the Arch G H, 64 deg. 29 min.
2. The height of the Pole or Stile above the Plain P R. A Ruler laid from *a* to P, will cut the Plain in *n*: So the distance R *n* measured, will be found to be 30 deg. 59 min.
3. The Substiles distance from the Meridian is the Arch L M 64 deg. 26 min.

4. The

4. *The Plains difference of Longitude* is the Angle Æ P Q , which to find, Lay a Ruler from P to Æ ; and it will cut the Plain in D , the distance D L , measured upon the line of Chords, will give 76 deg. 10 min. for the Plains difference of Longitude.

To Draw the Hour-lines upon the Plain.

First, Lay a Ruler upon P the Pole of the World, and Æ , the intersection of the Meridian with the Horizon, and it will cut the Plain in D , at which point being to divide the Semicircle æ L into 12 equal parts, at the points $\odot \odot \odot \&c.$

Secondly, Lay a Ruler from Q to the several points $\odot \odot \odot \&c.$ and it will divide the Equinoctial Circle into 12 unequal parts in the points $\times \times \times \&c.$

Thirdly, A Ruler laid from P to every of these unequal parts $\times \times \times \&c.$ will cut the Plain in these marks $| | | \&c.$ dividing that into 12 other unequal parts.

Lastly, If you draw right-lines from Q , through every of these marks $| | | \&c.$ they shall be the true hour-lines belonging to your Plain.

The Stile may be either of Wyre or Plate, as in other Dials, and must be elevated above the Substile, to an Angle of 30 deg. 59 min. and must stand square, or at the Right-angles to the Plain.

Q

The

the Complement of the Reclination of the plain; namely, 36 deg. — Or Geometrically thus. Draw the right-line kO , which divide into two equal parts in n , and upon the point n , raise a perpendicular nm , extending it till it cut the line SB in m , so shall m be the Centre of the Horizontal Circle HkO .

Thirdly, Lay a Ruler from H to e , it will cut the line SB (being extended) in the point N , so shall N be the Nadir point.

Fourthly, Because the Plain declines 60 deg. from the North Westward; set 60 deg. from B to d , and laying a Ruler to Z , the Zenith, (which is also the Pole of the Horizon) to d , it will cut the Horizon in s , through which point the Meridian must pass.

Fifthly, Take (always) 90 deg. of your Chord, and set that distance from d to e , and laying a Ruler from Z to e , it will cut the Horizon in W , the West point thereof, and a line drawn from W , through Q the centre of your Plain, will cut the Horizon (if you extend it, as here is done) in E , the East point thereof, and in some part of this line (extended if need require) will the Centre of the Meridian be, and where that point will fall may be thus found.

Sixthly, Divide the line ZN into two equal parts in F , and upon F erect the perpendicular FD , cutting the line EW (extended) in D , so shall D be the Centre of the Meridian of the place.

Seventhly, If with your Compasses you take the distance DR , and with that extent upon D , as a Centre, describe a Circle, you shall find that Circle exactly to pass through the respective points Z and N , if there be no former error committed in your work.

Eighthly, Because the height of the Pole above the Horizon, is equal to the Latitude of the place, viz. at London 51 deg. 32 min. set off 51 deg. 32 min. upon

on the Meridian from s to P , in this manner.

Ninthly, Lay a Ruler from W , the West point of the Horizon, (which is also the Pole of the Meridian) to s and it will cut the Plain in h , then set 51 deg. 32 min. from h to f . A Ruler laid from W to f , it will cut the Meridian in P so is P the Pole of the World, distant from Z the Zenith, 38 deg. 28 min. and a line drawn through P , the Po'e of the World, and Q , the Centre of the Plain, will be the Axis of the World, and (extended) will cut the Meridian in M the South Pole.

Tenthly, The Meridian and Horizon being thus drawn, it is easie to describe the Equinoctial, for if you consider the position of that Circle in the Sphere it self, you know that it alwayes passes through the East and West points of the Horizon, and cutteth the Meridian at right Angles, it being in all places 90 deg. distant from either of the Poles. Wherefore, if upon W , (the Pole of the Meridian) you lay a Ruler to P , the Pole of the World, it will cut the Plain in f , and if you set 90 deg. from f to g , and lay a Ruler from W to g , it will cut the Meridian in \mathcal{A} , so have you three points, through which the Equinoctial must pass, namely E \mathcal{A} and W , and the Centre of the Equinoctial will alwayes be in the Axis of the World, extended if need require. To find which, you must

Eleventhly, Divide the line $W E$ into two equal parts in G , and from the point G , upon the line $E W$, erect the perpendicular $G K$, cutting the Axis of the World in K , so shall K , be the Centre of the Equinoctial, wherefore, if upon K as a Centre, with the distance $K W$, you describe a Circle, that shall be the Equinoctial, and (if your work be true) shall pass through the points E \mathcal{A} W : Then for the dividing of the Equinoctial.

Twelfthly, Lay a Ruler to P , the Pole of the World,
(which

The Third Variety.

C H A P. XXV.

How to draw the Hour-lines upon a North Reclining or Inclining Plain, Declining East or West, which intersects the Meridian, between the Equinoctial and the Horizon.

LET this third and last Example of North Recliners Declining, be of a North Plain, Reclining 54 deg. and Declining Westward 60 deg. in the Latitude of *London* 51 deg. 32 min.

This being the third and last Variety of Declining Reclining Plains, I shall be somewhat the larger in the projection thereof, than I have been in any of the foregoing; not but that this Dial is to be made in all respect like (and with the same case) as the former. But herein I shall shew at large the manner of projection, and how all the Centres are Geometrically found, and the reasons of their being in such and such lines, and at such and such distances. And also, I shall project all the hour-lines, belonging to the Plain upon the Plain itself by circular lines, by which means the Reader may attain to a more competent knowledge in what hath been heretofore in this Treatise delivered. For from this Projection following, all the aforesaid hath been deduced. And therefore I shall describe the manner of the declining of this Dial, according to the following Proposition.



PROPOSITION.

A Circle being described representing a Declining Reclining Dial Plain's how it becom to place the Meridian, Horizon, Equinoctial, Pole, Zenith, &c. with all other Requisites belonging to such a Dial. And also to Project the Meridians of the Sphere it self upon the Plain, and from thence to draw the Hour-lines upon the Dial-plain, according to their true situation.

L Et the Circle H S O B, represent a Dial-plain in the Latitude of London 51 deg. 32 min. Declining from the North towards the West 60 deg. 00 min. and Reclining from the Zenith Northward 54 deg. 00 min.

First, Cross the Circle with the two Diameters H O, and S B, cutting each other at Right angles in the Centre Q. And because the Plain Reclineth 54 deg. 30 min. take 54 deg. 30 min. out of your Line of Chords, and set that distance upon your Plain, from S to a, from O to b, and from B to c. Then lay a Ruler from H to a, and it will cut the Line S B in Z, so shall the point Z be the Zenith of the place.

Secondly, Lay a Ruler from H to b, it will cut the line S B in k, so shall k be a point in the line S B, through which the Horizon shall pass. And thus having three points H, O, you may through them describe the Horizon, whose Centre will be at m, the distance in k, being equal to the Secant of

the Complement of the Reclination of the plain; namely, 36 deg. — Or Geometrically thus. Draw the right-line kO , which divide into two equal parts in n , and upon the point n , raise a perpendicular nm , extending it till it cut the line SB in m , so shall m be the Centre of the Horizontal Circle HkO .

Thirdly, Lay a Ruler from H to e , it will cut the line SB (being extended) in the point N , so shall N be the Nadir point.

Fourthly, Because the Plain declines 60 deg. from the North Westward; set 60 deg. from B to d , and laying a Ruler to Z , the Zenith, (which is also the Pole of the Horizon) to d , it will cut the Horizon in s , through which point the Meridian must pass.

Fifthly, Take (always) 90 deg. of your Chord, and set that distance from d to e , and laying a Ruler from Z to e , it will cut the Horizon in W , the West point thereof, and a line drawn from W , through Q the centre of your Plain, will cut the Horizon (if you extend it, as here is done) in E , the East point thereof, and in some part of this line (extended if need require) will the Centre of the Meridian be, and where that point will fall may be thus found.

Sixthly, Divide the line ZN into two equal parts in F , and upon F erect the perpendicular FD , cutting the line EW (extended) in D , so shall D be the Centre of the Meridian of the place.

Seventhly, If with your Compasses you take the distance DR , and with that extent upon D , as a Centre, describe a Circle, you shall find that Circle exactly to pass through the respective points Z , and N , if there be no former error committed in your work.

Eighthly, Because the height of the Pole above the Horizon, is equal to the Latitude of the place, viz. at London 51 deg. 32 min. set off 51 deg. 32 min. upon

on the Meridian from s to P , in this manner.

Ninthly, Lay a Ruler from W , the West point of the Horizon, (which is also the Pole of the Meridian) to s and it will cut the Plain in h , then set 51 deg. 32 min. from h to f . A Ruler laid from W to f , it will cut the Meridian in P so is P the Pole of the World, distant from Z the Zenith, 38 deg. 28 min. and a line drawn through P , the Po'e of the World, and Q , the Centre of the Plain, will be the Axis of the World, and (extended) will cut the Meridian in M the South Pole.

Tenthly, The Meridian and Horizon being thus drawn, it is easie to describe the Equinoctial, for if you consider the position of that Circle in the Sphere it self, you know that it alwayes passes through the East and West points of the Horizon, and cutteth the Meridian at right Angles, it being in all places 90 deg. distant from either of the Poles. Wherefore, if upon W , (the Pole of the Meridian) you lay a Ruler to P , the Pole of the World, it will cut the Plain in f , and if you set 90 deg. from f to g , and lay a Ruler from W to g , it will cut the Meridian in \mathcal{A} , so have you three points, through which the Equinoctial must pass, namely E \mathcal{A} and W , and the Centre of the Equinoctial will alwayes be in the Axis of the World, extended if need require. To find which, you must

Eleventhly, Divide the line $W E$ into two equal parts in G , and from the point G , upon the line $E W$, erect the perpendicular $G K$, cutting the Axis of the World in K , so shall K , be the Centre of the Equinoctial, wherefore, if upon K as a Centre, with the distance $K W$, you describe a Circle, that shall be the Equinoctial, and (if your work be true) shall pass through the points E \mathcal{A} W : Then for the dividing of the Equinoctial.

Twelfthly, Lay a Ruler to P , the Pole of the World,
(which

(which is also the Pole of the Equinoctial) to \mathcal{A} , the intersection of the Meridian and Equinoctial, and it will cut the Plain in the point $\mathcal{r}2$ at which point you must begin to divide the Circle representing your Reclining declining Plain, into 24 equal parts at the points $\odot \odot \odot$, &c. This done, lay the Ruler to the point \mathcal{P} , and every of the 24 equal parts $\odot \odot \odot$, and you shall find it to cut the Equinoctial Circle in the points $\mathbf{x} \mathbf{x} \mathbf{x} \mathbf{x}$, &c. dividing that Circle into 24 unequal parts, through which unequal parts, and the two Poles of the World \mathcal{P} and \mathcal{M} , must all the hour-circles pass For the describing whereof you must

Thirteenthly, Divide the line $\mathcal{P} \mathcal{M}$ into two equal parts in the point \mathcal{L} , [or, from the point \mathcal{D} , the Centre of the Meridian, let fall a Perpendicular upon the Axis of the World, which will fall in the same point \mathcal{L} ,] and through the point \mathcal{L} draw an infinite right-line at right-angles to $\mathcal{P} \mathcal{M}$, namely the line $\mathcal{C} \mathcal{T}$, for in that line will the Centres of all the hour-circles be found, and the manner how to find them, is thus (one way) to be effected.

Fourteenthly Upon the point \mathcal{P} as a Centre, at the distance $\mathcal{P} \mathcal{L}$, [or to any other radius of a line of Chords] describe the semicircle $\mathbf{X} \mathcal{L} \mathbf{V}$, and divide it into 12 equal parts at the points ---, &c. beginning your division at the point \mathcal{J} , which is, where the Ruler being laid from \mathcal{P} to \mathcal{D} (the Centre of the Meridian) cut this last drawn Circle. Then laying a Ruler from \mathcal{P} , upon each of these divisions, you shall find it to cut the line $\mathcal{C} \mathcal{T}$ in the points 15, 30, 45, 60, &c. on either side of the point \mathcal{D} . And here note, that 15 is the Centre of the first hours distance from the Meridian on either side thereof, 30 the Centre of the second, and 45 of the third hours distance, from the Meridian, &c.

Fifteenthly, If you place one foot of your Compasses upon 15, and extend the other to \mathcal{P} , the Pole of the World, and

and with that distance describe a Circle, that Circle shall be the first hour from the Meridian, and (if your work be true) shall pass through M the South Pole, and also through $\phi\phi$, the two first unequal divisions of the Equinoctial Circle, and so all the rest.

Lastly, If from Q the Centre of your Plain, and the respective points where the hour-circles cut the Plain, you draw straight-lines, those shall be the true hour-lines proper for such a Declination and Reclination, as you formed your Projection for.

Now the Requisites belonging to this, and the like Declining Reclining Plain, are

		deg.	min.
1. The height of the Pole above the Plain.	P A	54	43
2. The distance of the Meridian and Horizon.	repre- Hr	53	31
3. The distance of the Substile from the Meridian.	sented by r A	56	41
4. The angle between the two Meridian.	Æ P R	61	47

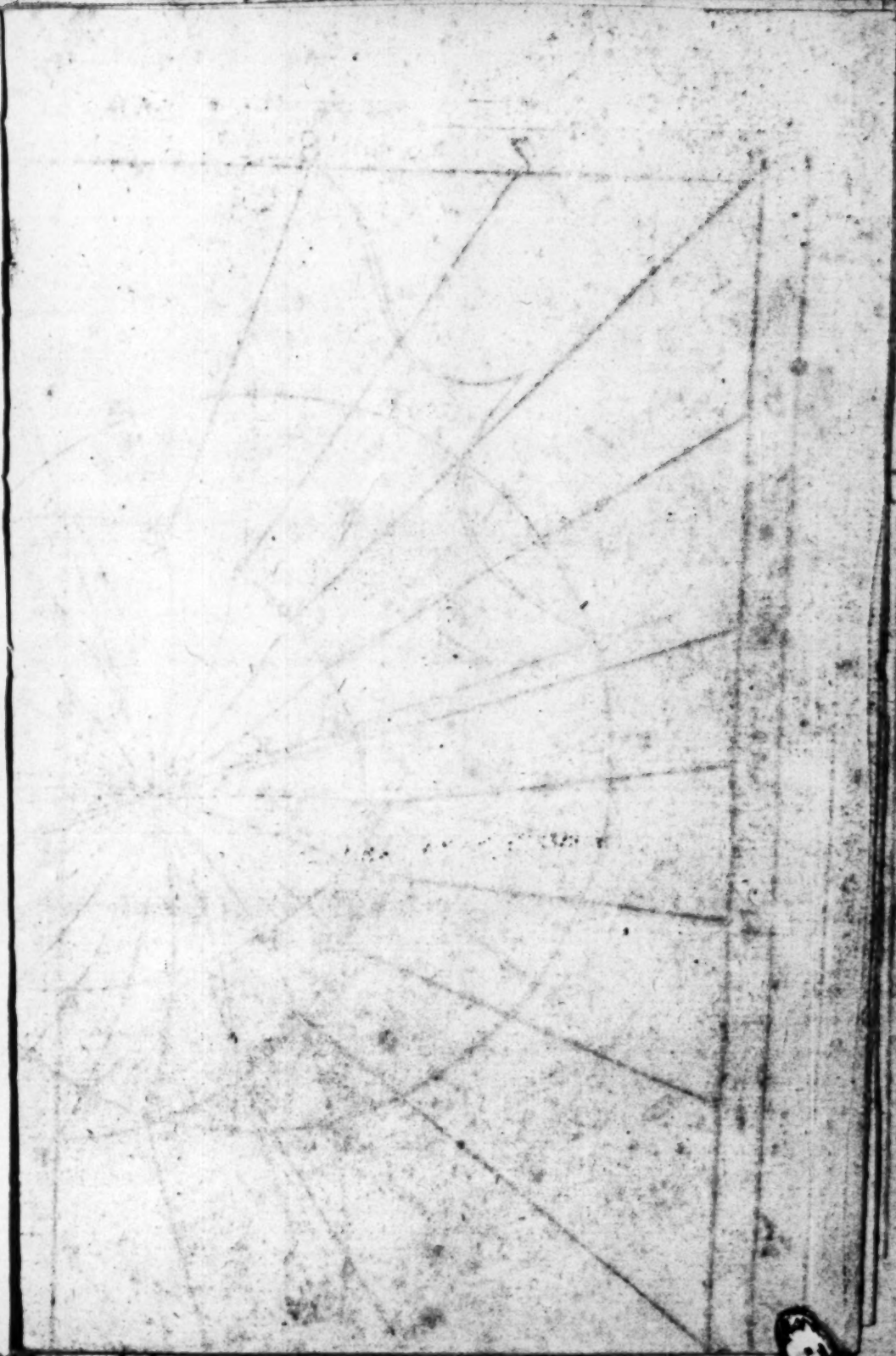
All which may be measured upon the Projection, and for their quantities found. As,

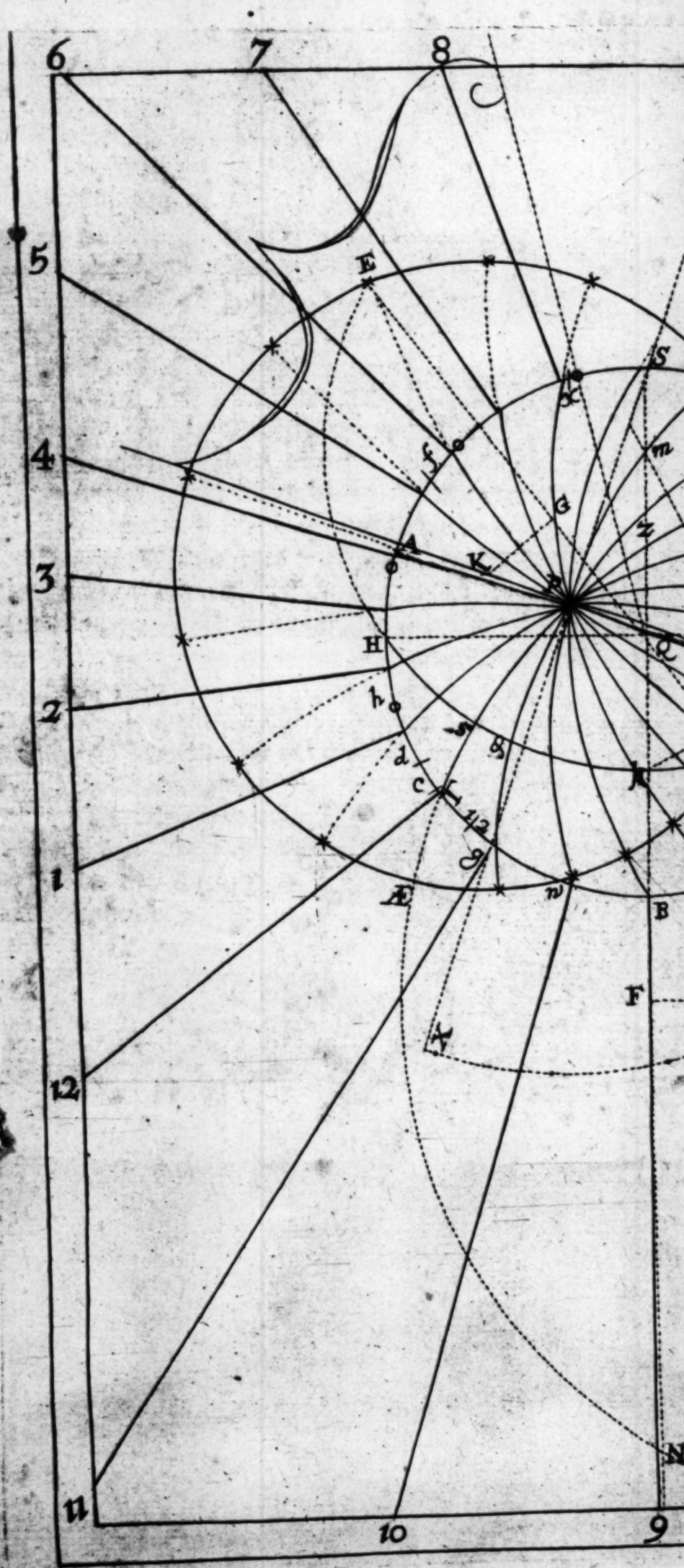
1. To find P A, Lay a Ruler from P to w, where the Equinoctial and the Plain do intersect, and the Ruler will cut the Plain on the other side at x, so A x measured upon the Line of Chords, will be 54 deg. 43 min. the height of the Pole above the plain, [or P Q measured upon a line of half Tangents, will contain 35 deg. 17 min.] the complement thereof.

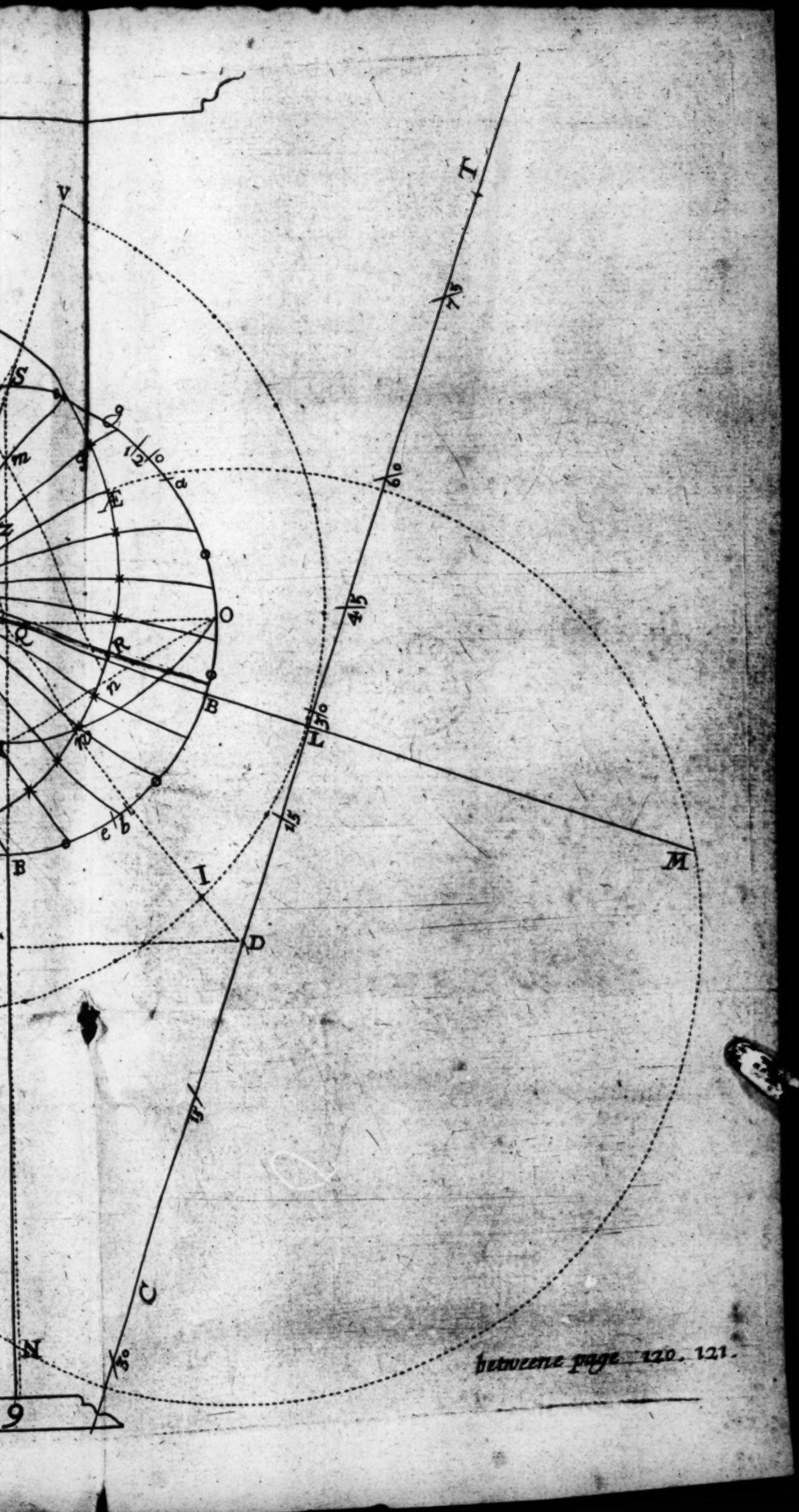
2. To

2. To find Hr , the arch Hr , measured upon the Line of Chords, will give 53 deg. 31 min. the distance of the Meridian from the Horizon.
3. To find rA , the Arch rA measured upon the Line of Chords, will give 56 deg. 41 min. the distance of the Substile from the Meridian.
4. To find $\angle PRQ$, Lay a Ruler to P the Pole of the World, and \mathcal{A} , the intersection of the Meridian and the Equinoctial, and it will cut the Plain in θ , the arch θB , measured upon the line of Chords, will be found to contain 61 deg. 47 min. which is the Angle between the two Meridians.

Thus have you in this Scheme deliveted the true and genuine way of Delineating of Sun-dia's deduced from the Sphere it self, by which the Reason of all that hath been before delivered is rendred obvious, and sufficiently demonstrative for this place. But here you see, that the Centres of the Meridians or Hour-circles fall out to be very remote, and that there will be required a large Tangent-line for their description, which will (for the most part) run out very far, and sometimes almost to an infinite excursion. I therefore chose rather to shew how the hour-lines might be drawn without having any regard to this Tangent-line, or without projecting of the hour-lines upon the Circular-plain, and therefore the ways before delivered are far more apt for practice than this, though this be more satisfactory to the inquisitive Reader, who will not be satisfied only with the doing, but off the understanding as well of what he does, and it is for the satisfaction of such that I have here added this Proposition.







between page 120. 121.



C H A P. XXVII.

Concerning Inclining Plains, both direct and Declining.

OF Reclining Plains there are but two sorts, as hath been before instanced, and those are either *Direct* or *Declining*. The *Direct* are those Reclining Plains, which do directly behold the *East*, *West*, *North*, or *South* points of the Horizon. And the *Decliners* are those which (besides their Reclination from the Zenith) do respect two of the fore-mentioned Cardinal points, as

- (1.) The *South* and the *West*.
- (2.) The *North* and the *West*.
- (3.) The *South* and the *East*.
- Or (4.) The *North* and the *East*.

The First
Second
Third
Fourth
sort are
called
South
North
declining West
declining East
Reclining

I also before intimated, and gave examples, that of *Direct* Recliners, there were three sorts, viz.

1. Such as Reclining from the Zenith, do behold either the due *East*, or due *West* points of the Horizon; and of this sort there is only one kind, and no variety in any case.

2. *South Recliners*, of which there are three Varieties.

And 3. *North Recliners*, of which also there are three Varieties.

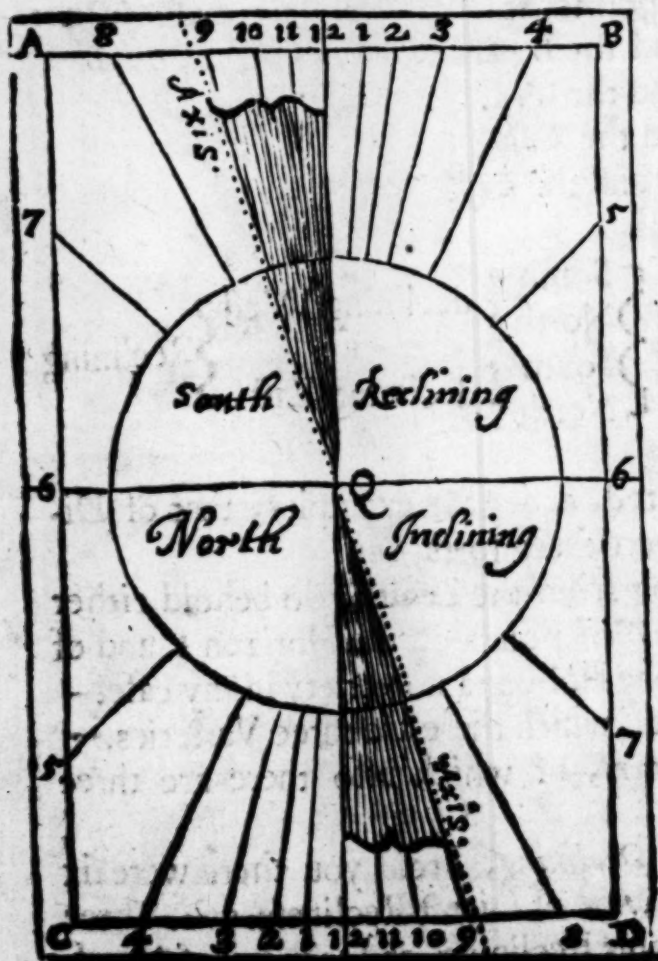
Again, of *Reclining Declining*, I told you there were six Varieties also, as there were of *Direct* Recliners, viz. Three of *South Declining Plains Reclining*, and as many of *North*

R

Reclining

Reclining Declining Plains ; of all which I have given Examples, and it may be now expected that I should do the like for the Inclining Plains opposite to them, of which there are also as many Varieties, but seeing that the making of the Reclining Dial, whither Direct or Declining, doth also make the Inclining Dial, whither Direct or Declining opposite thereunto, I shall save the labour, and commend to the ingenious Reader some few Rules, by which he shall easily frame the Inclining Dial out of the Recliner. And

I. Of North and South Incliners.



I will take for Example a South Plain Reclining 55 deg. which is the third Variety of South Recliners, and I would from that deduce the hour-lines proper for a North Plain Inclining as much, viz. 55 deg. And it is easily affected. For,

If you draw the hour-lines of the South Recliner 6 A B 6, and the Stile thereof also, quite through the Centre Q, to the opposite part of the plain, 6 C D 6, and set the same

same numbers to the hours on the right-hand in the Recliner, and the contrary, as the Figure clearly demonstrates: And let the Axis in the North Incliner, point downwards to the South Pole. As the Axis in the South Recliner doth upwards to the North Pole, and your Dial is finished. Or you may effect this work by pricking off the hour-lines through the Paper, and turning it upside down, and that will effect the same thing, only changing of the names of the hours. Or again, If you turn the South Reclining Plain ϕ A B ϕ about, upon the Centre Q, till the line A B come to be in the place of C D, then will the hours, stile and all, be truly named and posited; and the very South Recliner will now become the North Incliner without any alteration.

II. Of East and West Incliners.

There is little difference in drawing of the East or West Inclining Dials, from the Reclining Dials opposite to them, then there was of drawing of the North Incliner before, from the South Recliner. For,

In the Example of the East and West Reclining and Inclining Dial, before going Chapter 10. The Dial as it there stands represents an East or West Reclining Plain. But if you turn the Dial about upon the Centre Q, till the letter N come to be in the place of the letter S, in that figure, then will the same Dial represent both an East an West Dial Inclining 35 deg. as now it doth an East or West Reclining as much. The Substile, Stile, Meridian, and the rest of the Hour-lines retaining the same names or denominations, as now they do.

III. *Of North or South Declining Inclining Plains.*

Of North and South Reclining Declining Plains, there were six Varieties, Examples of each have been largely given. There are as many of North and South Incliners, but seeing they may be so easily deduced out of their opposite Recliners, I shall forbear giving Examples, and the way is not much differing from the Rules before given for Direct Reclining and Inclining Plains. For seeing the Reclination is alike proper to each, and the Deflexion of the Substile from the Meridian in the Declinations do so directly agree, they may both be reduced to one and the same Dial as the other were.

Thus, if any Rec'ining Dial be so inverted, that the upper part thereof, become the neither, and after this inversion the right-side of the Recliner, become the left-side of the Incliner, and the contrary, the Inclining Dial having the same Declination, shall be framed out of the Recliner, and the contrary. Only the Denominations of the Hours must be changed. For the forenoon Hours in the Recliner, will be the afternoon Hours in the Incliner, and the afternoon Hours of the upper Dial, the forenoon Hours of the neither.

C H A P. XXVIII.

A general Rule to know which Pole, whether the North or the South, is to be elevated over any Plain.

THe Stile of every Dial respecteth (or rather lyeth parallel with) the Axis of the World, and always pointeth upwards or downwards, to one of the Poles. Now when

when you have drawn your Dial (though truly) you may be to seek, whether it be the North or the South Pole that must be elevated; wherefore to avoid any mistake, and to inform you which Pole is to be elevated. Observe this general Rule.

Upon all Upright Plains, { South } side the { South } Pole.
 whether Direct or De- { North }
 clining, upon the { North }

Upon all East { Recliners } the { North } Pole.
 and West { Incliners } { South }

Upon all { North Recliners } whither { North } Pole.
 { South Incliners } Direct or { South }
 Declining

Upon all { South Re- } whither { If the } Zenith { and } South
 { North In- } Direct { Plain pass } Nadir { the } North Pole
 { Incliners } or De- { between } Horizon { the } South
 Declining

* This Rule being duly observed, there will be no difficulty to find which Pole is elevated.

The End of the First Part.

Geometrical Dialling.

When you have drawn your Dial (the way) you may
 be to look whether it be the front of the Dial, and if it
 must be elevated, you are to avoid any mistake, and to
 inform you which Pole is to be elevated. Observe this ge-
 metrical Rule.

Upon all Right Lines, whether Direct or Re-
 versed, upon the North Pole.

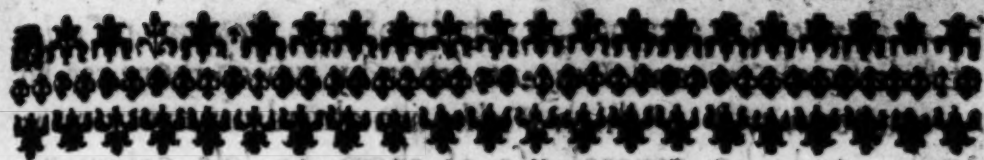
Upon all Right Lines, whether Direct or Re-
 versed, upon the South Pole.

Upon all Right Lines, whether Direct or Re-
 versed, upon the North Pole.

Upon all Right Lines, whether Direct or Re-
 versed, upon the South Pole.

This Rule being duly observed, there will be no difficulty
 to find which Pole is elevated.

The End of the First Part.



The *ART* of
DIALLING,
ARITHMETICALLY

Performed:

By the *CANONS*, or *TABLES* of Artificial
Sines and Tangents.

PART. II.

The Argument.

VV Hereas the *Geometrical* delineating, or making of *Sun-dials*, may be rejected by some, and a more accurate performance of the same required by others. I thought good to make this *Treatise* the more compleat, (which for a *Geometrical* way is already perfect enough) to add the *Canons*, *Analogies* or *Propor-*

Proportions, by which the several *Requisites* in all *Plains* may be *Arithmetically* attained, by help of the *Canons* or *Tables* of *Artificial Sines* and *Tangents* (then by which there can be no exacter way.) Which *Tables* are already in every mans hands, and the general use of them no less common: Wherefore I shall say nothing of that in this place, but proceed to the finding of the forementioned *Requisites*, as followeth. And

S E C T. I.

Of (Vertical or) Horizontal Plains.

IN these Plains there is nothing required but the *Height of the Pole above the Plain*, which, in all Places, is equal to the *Latitude* of the Place, for which the Dial is to be made.

S E C T. II.

Of North and South Erect Direct Plains.

IN these Plains also there is nothing required but the *height of the Pole above the Plain*, which in all Places is equal to the *Complement* of the *Latitude* of the Place. Wherefore, *Subtract* the *Latitude* of the Place, for which your Dial is to be made from 90 deg. and the *Remainder* is the *height of the Pole above the South or North Erect Direct Plain*:

	deg.	min.
From	90	00
Subtract. Latitude	51	32
There remains	38	28

Which

Which is the height of the Pole above a Direct North or South Plain, in the Latitude of 51 deg. 32 min.

S E C T. III.

Of North and South Erect Declining Plains.

But in Erect Declining Plains, (besides the Latitude of the Place, and the Declination of the Plain) three things are requisite to be found, before you draw the Dial, and they are,

1. The height of the Stile (or Pole) above the Plain.
2. The distance of the Substile from the Meridian.
3. The Plains difference of Longitude.

Example, In the Declining Plain in Chap. 8. whose Declination was 34 deg. 20. min. in the Latitude of 51 deg. 32 min.

1. For the height of the Pole above the Plain.

As the Radius 90 deg.	10.000000
Is to the Co-sine of the Latitude 58 deg.	9.793831
28 min.	9.959596
So is the Co-sine of the Declination.	19.73427

To the Sine of 34 deg. 33 min.	19.73427
--------------------------------	----------

Which 34 deg. 33 min. Is the height of the Pole above the Plain.

2. For the distance of the Substile from the Meridian.

As the Sine of 90	10.000000
Is to the Sine of the Plains Declination	9.616059
34 deg. 20.	9.900086
So is the Co-tangent of the Latitude 38 d. 28 m.	19.516145

To the Tangent of 18 deg. 10 min.	19.516145
S	Which

Which 18 deg. 10 min. is the distance of the Substile from the Meridian.

3. For the Plains difference of Longitude.

As the Co-sine of the Latitude 38 d. 28 m.

9.793831

Is to the Radius 90 deg.

10.000000

So is the Sine of the distance of the Substile from the Merid. 18 deg. 10 min.

19.493851

To the Sine of 30 deg. 00 min.

9.6699201

Which 30 deg. 00 min. is the Plains difference of Longitude.

S E C T. I V.

Of South Direct Reclining Plains.

IN these Plains, (the Latitude of the Place, and the Reclination of the Plain being given) there is only required *The Height of the Pole above the Plain*: In which there are two Cases, in both which you may find the Stiles height, as followeth.

1. If the Reclination of the Plain, be less than the Complement of the Latitude, Subtract the Reclination out of the Complement of the Latitude, and the remainder will be the height of the Pole or Stile above the Reclining Plain. But
2. If the Reclination of the Plain be more than the Complement of the Latitude, Subtract the Complement of the Latitude from the Reclination, and the Remainder shall be the Elevation of the Pole above the Plain.

1. Case

		deg. min.
1. Case	Latitude 51 deg. 32 min. Comple.	38 28
	Reclination.	22 10

	Height of the Pole above the Plain	16 18
2. Case	Reclination	62 23
	Latitude 51 deg. 32 min. Comp.	38 28

	Height of the Pole above the Plain.	23 55

S E C T. V.

Of North Direct Reclining Plains.

IN these Plains also (the Latitude and Reclination being given) there is only required *The Height of the Pole above the Plain.*

To find this.

Add the Complement of the Latitude, to the Reclination, and the sum of them is the height of the Pole above the Reclining Plain.

	deg. min.
Latitude 51 deg. 32 min. Compl.	38 28
Reclination	27 12

Height of the Pole above the Plain. 65 40

But if this sum exceed 90 deg. then Subtract it from 180 deg. and the remainder shall be the height of the Pole above the Plain.

	deg. min.
Latitude 51 deg. 32 min. Complement	38 28
Reclination	70 42
	<hr/>

	sum. 109 10
Which Subtract from:	180 00
There remains	70 50

Which 70 deg. 50 min. is the height of the Pole above the Plain.

S E C T. VI.

Of East and West Direct Reclining Plains.

IN East and West Reclining plains (the Latitude of the Place, and Reclination being given) there are required the same three things as in North and South Erect Decliners, namely,

1. The height of the Pole (or Stile) above the Plain.
2. The distance of the Substile from the Meridian.
3. The Plains difference of Longitude.

Example, Of the East or West Reclining Plain Part 1.

Chap. 10. whose Reclination was 35 deg. 00 min. and Latitude 51 deg. 32 min.

1. For the height of the Pole (or Stile) above the Plain.

As the Radius 90 deg.

10.00000

Is to the Sine of the Latitude 51 deg. 32 min.

9.89347

So is the Sine of the Reclination 35 deg.

9.75859

To the Sine of 26 deg. 41 min.

19.65206

Which 26 deg. 41 min. is the height of the Pole above the Reclining Plain.

2. For

2. For the distance of the Substile from the Meridian.
As the Radius 90 deg. 10.00000

Is to the Tangent of the Latitude 51 d. 32 m. 10.09991
So is the Co-sine of the Reclination 35 deg. 19.91336

To the Tangent of 45 deg. 52 min. 10.01327
Which 45 deg. 52 min. is the Substiles distance from
the Meridian.

3. For the Plains difference of Longitude.
As the Sine of the Latitude 51 deg. 32 min. 9.89374

Is to the Radius 90 deg. 10.00000
So is the Sine of the Substiles distance 2
from the Meridian 45 deg. 52 min. 19.85595

To the Sine of 66 deg. 27 min. 9.96221
Which 66 deg. 27 min. is the Plains difference of Lon-
gitude.

S E C T. VII.

Of South and North Declining Reclining Plains.

IN Declining Plains Reclining, (besides the Latitude of
the Place, Declination and Reclination of the Plain;
which are for the most part given) there must four things be
found before you can draw the Dial, viz.

1. The distance of the Meridian and Horizon.
2. The height of the Pole or Stile.
3. The distance of the Substile from the Meridian.
4. The Plains difference of Longitude.

Look in
page 101

Of these Plains you have in the 20, 21, 22, 23, 24, and 25. Chapters of the first Part six Varieties, which are all that in any case may happen, viz. Three of South Declining Reclining, and as many of North Declining Reclining. I shall only instance in two of them, viz. one of a South Reclining Plain Declining Easterly, and another of a North Reclining Plain Declining Westerly. The Example of the South Recliner shall be that in the third and last Variety of South Decliners Reclining, and that is of a South Plain, declining Easterly 30 deg. and Reclining 55 deg. as in Part I. Chap. 22.

I. In South Decliners Reclining,

1. For the distance of the Meridian from the Horizon.
As the Radius 90 deg.

10.00000

Is to the Sine of the Reclination 55 deg.
So is the Tangent of the Declination 30 deg.

9.91336

9.76144

To the Tangent of 25 deg. 19 min. 19.67480

Which 25 deg. 19 min. being taken from 90 deg. leaves 64 deg. 41 min. the distance of the Meridian from the Horizon.

2. For the height of the Pole (or Stile) above the Plain.

This will require two Operations.

1. As the Radius 90 deg.

10.00000

Is

Arithmetical Dialling.

135

Is to the Sine of the distance of the Meridian from the Horizon 64 d. 41 m. } 9.95615

So is the Co-sine of the Reclination 35 deg. } 9.73859

To the Sine of 31 deg. 14 min. } 19.41474

Which 31 deg. 14 min. being less than the Latitude 51 deg. 32 min. Subtract it there from, and there will remain 20 deg. 18 min.

Then say again,

2. As the Sine of the distance of the Meridian from the Horizon 64 deg. 41 m. } 9.95615

Is to the Sine of the Arch last found 20 d. 18 m. } 9.54025

So is the Co-sine of the Declination 60 deg. } 9.93753

19.47778

To the Sine of 19 deg. 25 min. } 9.52163

Which 19 deg. 25 min. is the height of the Pole or Stile above the Plain.

Note that if the Arch found at the first of these Operations be equal to the Latitude of the Place (as there it was lesser, viz. but 31 deg. 14 min.) then the Reclining Plain had been an Equinoctial Decliner, and must be made as by the precepts delivered in the 20th. Chap. of the first Part.

3. For the distance of the Substile and Meridian.

As the Co-tangent of the Declination 60 deg. } 10.23856

Is to the Sine first found in the last proportion, viz. 31 deg. 14 min. } 9.71477

So is the Tangent of the height of the Pole above the Plain, 19 deg. 25 min. } 9.54714

19.26191

To the Sine of 6 deg. 2 min. } 9.02335

Which

Which 6 deg. 2 min. is the distance of the Substile from the Meridian.

4. *For the Plains difference of Longitude.*

As the Sine of the difference of the Arch
first found, and the Latitude of the
Place, viz. 20 deg. 18 min.

Is to the Radius 90 deg.

So is the Sine of the Substiles distance
from the Meridian 6 deg. 2 min.

9.54015

10.00000

19.02335

To the Sine of 17 deg. 38 min.

9.48320

Which 17 deg. 38 min. is the Plains difference of Longitude.

II. *In North Decliners Reclining.*

In all these Plains (as well as in South Recliners) four things must be found (besides the Latitude of the Place, and the Reclination of the Plain, which are commonly given) before the Dial can be drawn, and those are the same as in South Recliners, viz.

1. *The distance of the Meridian from the Horizon.*
2. *The height of the Pole or Stile above the Plain.*
3. *The distance of the Substile from the Meridian.*
4. *The Plains difference of Longitude.*

All these may be found by the following *Canons* or *Analogies*. And for an Example, I shall make use of the North Plain Declining Westerly 60 deg. and Reclining 54 deg. as in the last Example of North Recliners, Chap.

1. For the distance of the Meridian from the Horizon.

As the Radius 90 deg. 10.00000

Is to the Sine of the Reclination 54 deg. 9.90795

So is the Tangent of the Declination 60 deg. 10.23856

To the Tangent of 54 deg. 29 min. 10.14658

Which 54 deg. 29 min. being taken from 90 deg.
leaves 35 deg. 31 min. And that is the distance of
the Meridian from the Horizon.

2. For the height of the Pole (or Stile) above the Plain.

This also will require two Operations.

1. As the Sine of the Declination 60 deg. 9.93753

Is to the Radius 90 deg. 10.00000

So is the Co-sine of the distance of the Me-
ridian from the Horizon 54 d. 29 min. 19.91059

To the Sine of 70 deg. 2 min. 9.97306

To this 70 deg. 2 min. add the Complement of the
Latitude, 38 deg. 28 min. the sum will be 108 deg.
30 min. and this Arch (being above 90 deg.) take it
from 180 deg. so will there remain 71 deg 30 min.

2. As the Sine of the Arch first found 70 d. 2 m. 9.97306

Is to the Sine of the Reclination 54 d. 0 m. 9.90796

So is the Sine of the Arch last found 71 d. 30 m. 9.07695

To the Sine of 54 deg. 43 min. 9.91185

Which 54 deg. 43 min. is the height of the Pole or
Stile above the Plain.

Note, That if the Arch first found, viz. 70 deg. 2 mi. had been just 90 deg. the Plain then had been a Polar declining Plain, the Substile and the hour of six being the same, and must be made by the Precepts delivered in Chapter.

3. *For the distance of the Substile and Meridian.*

As the Tangent of the Reclination 54 deg. 10.13874

Is to the Sine of the Arch first found, }
viz. 54 deg. 29 min. } 9.91059

So is the Tangent of the height of the } 10.15021

Pole above the Plain 54 d. 43 min. }
20.06080

To the Sine of 56 deg. 42 min. 9.92206

Which 56 deg. 42 min. or rather the Complement thereof to 180 deg. viz. 123 deg. 18 min. is the distance of the Substile from the Meridian, according as you please to account it, either from the North or from the South.

4. *For the Plains difference of Longitude.*

As the Sine of the height of the Pole above }
the Plain 54 deg. 43 min. } 9.91184

Is to the Tangent of the distance of the }
Substile and Meridian 56 deg. 42 m. } 10.18251

So is the Radius 90 deg. 10.11111

To the Tangent of 61 deg. 48 min. 10.27067

Which 61 deg. 48 min. is the Plains difference of Longitude counted from the North, or the Complement thereof to 180 deg. viz. 118 deg. 12 min. is the same difference of Longitude counted from the South.

S E C T. VIII.

Of the Hour Distances upon the Plains.

Hitherto you have in a general, plain, and easie method (and of all others the most exact) delivered, the manner how to calculate the requisites belonging to all sorts of Plains, whither *Direct*, *Reclining*, *Declining*, or *both*. It resteth now, to find the true hour distances one from another upon any of these Plains, and for that (for all Dials which have Centres) there is only one general *Analogy* or *Proportion*, and that is this. Having found the Plains difference of Longitude; say,

As the Radius, or Sine of 90 deg.

Is to the Sine of the height of the Pole or Stile above the Plain.

So is the Tangent of each hours distance (upon the Equinoctial) from the Substile,

To the Tangent of the same hours distance upon the Plain, counted from the Substile.

Now, (because Examples do more confirm the fancy than barely Precepts) I shall by President or Example make plain all that hath hitherto been delivered, and one shall serve instead of many, and that shall be in an Upright or Erect Declining Plain, (which of all Dials are the most common and useful.) Suppose therefore,

In Latitude 52 deg. 40 min. an Erect Plain beholding the South, to decline Westward 24 degrees.

The Arithmetical Calculation.

By the Rules delivered in the III. Section of these Precepts, you shall find,

1. The height of the Pole (or Stile) above the Plain, to be 33 deg. 38 min.
2. The distance of the Substile from the Meridian to be 17 deg. 14 min. And
3. The Plains difference of Longitude to be 29 deg. 15 min.

These Requisites being thus attained, the next thing is to find the hour distances upon the Plain, which may be done by the last foregoing Analogy.

But first, you are to consider the quantity of the Plains difference of Longitude, which here, in this Example, is found to be 29 deg. 15 min. And (because every hours distance upon the Equinoctial is 15 deg. distance from the Substile, so 2 hours is 30 deg. distance, and 3 hours is 45 deg. distance: This Plains difference of Longitude being above 15 deg.) which is one hours distance) and less than 30 deg. (which is two hours distance) the Substile (the Plain declining Westerly) must needs fall between the hours of 1 and 2. Wherefore, Subtract 15 deg. (1 hours distance) from 29 deg. 15 min. and there will remain 14 deg. 15 min.

the Equinoctial distance of 1 a clock from the Substile. Also from 30 deg. (which is 2 hours distance) Subtract 29 deg. 15 m. and the remainder will be 05 deg. 15 min. for the Equinoctial distance of 2 a clock from the Substile. Having found the Equinoctial distances of the two next hour-lines on either side of the Substile (as of 1 and 2) the rest are easily found by the continual addition of 15 deg. and so is the Column of the Equinoctial distances in the following Table made. Being thus prepared, the true hour distances from the Substile

Substile upon the Plain may easily be attained by the foregoing *Analogy*. I will instance in one hours distance for all, and give you the rest in a Table ; As,

Let it be required to find the distance of one a Clock upon the Plain from the Substile, Say,

As the Sine of 90 deg.

1000000

Is to the Sine of the height of the Stile }
33 deg. 38 min. }

9.74341

So is the Tangent of the Equinoctial distance }
of one a clock, viz. 14 deg. 15 min. }

9.40478

To the Tangent of 8 deg. 0 min.

19.14819

Which 8 deg. 0 min. is the distance of the one a clock hour-line upon the Plain from the Substile.

And in the same manner may you find the distance of 2 a clock to be 0 deg. 25 min. Of 3 a clock 8 deg.

53 min. Of 4 a clock 18 deg. 14 min. and so the rest, as in the following Table, for every whole hour.

And if you desire halves and quarters of hours, you must insert them in the Column of Equinoctial distances, allowing 7 deg. 30 min. for half an hour, and 3 deg. 45 min. for a quarter, and so 15 deg. for a whole hour.

Hours

	Hours Equinoctial distances		True hour distances	
	deg.	min.	deg.	min.
VIII	89	15	88	39
IX	74	15	63	1
X	59	15	42	57
XI	44	15	28	21
XII	29	15	17	14
I	14	15	8	0
II	0	45	0	25
III	15	45	8	53
IV	30	45	18	14
V	45	45	29	37
VI	60	45	44	41
VII	75	45	65	22

14 + 15 = 29 Substile

Substile

Thus have you the Arithmetical Calculation of the whole Dial, it remains now to shew how these hour-lines are to be transferred from the Table to the Dial plain, which is to be done as followeth.

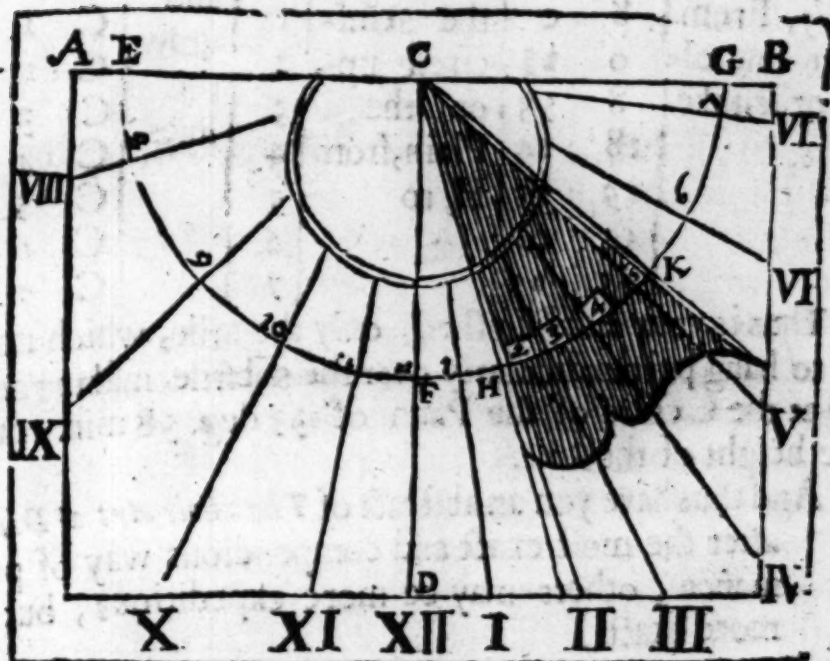
The Geometrical Projection.

First, (Upon your Dial-plain) draw an horizontal-line A B, and perpendicular thereunto another line C D, for the Meridian and hour-line of 12.

Secondly, Take 60. deg. out of your line of Chords, and setting one foot in C, with the other describe the Semicircle E F G.

Thirdly, Because the distance of the Substile from the Meridian was found to be 17 deg 14 min. take 17 deg. 14 min.

*South declining West 24 degrees,
Latitude 52 deg. 40 min.*



min. from your line of Chords, and set them upon the Semicircle from F to H, and draw the line C H for the Substile.

Fourthly, The height of the Stile being 33 deg. 38 min. set that distance upon the Semicircle from H to K, and draw the line C K for the Stile.

Fifthly, (Having recourse to your Table) take 88 deg. 39 min. out of your line of Chords, and set them upon the Semicircle from H to G, and draw the line C G, for the hour line of 8 of the clock.

Lastly,

Lastly, From your line of Chords, take	63	1	and set the same upon the semi- circle up- on the Plain, from H, to	9	and draw the lines	C	9	for the hour-lines.
	42	57		10		C	10	
	38	21		11		C	11	
	17	34		12		C	12	
	8	0		1		C	1	
	0	35		2		C	2	
	8	53		3		C	3	
	18	14		4		C	4	
	29	37		5		C	5	
	44	41		6		C	6	
	65	22		7		C	7	

Thus is your Dial finished, only the Stile, which must be set to hang perpendicularly over the substile, making an Angle at the Centre of the Plain of 33 deg. 38 min. equal to the height of the Stile.

And thus have you an abstract of *The whole Art of Dialling*, after the most exact and compendious way of performance, others may be more expeditious, but none more exact.

The End of the Second Part.



CONCLUSION.

IT will be to little purpose to be thus curious in finding of the true Positions of the Meridian Stile, Substile, and Hour distances in all Plains, as in the foregoing precepts is delivered, unless also we be as severe or strict in finding of the Stile or Position of the Plain, upon which the Dial is to be made. For, what will it signifie to make the Dial true, and place it in a wrong position. You are in the Geometrical part of this Book taught how to find the Declination of any Plain, and for the finding of it, to attain to the true Azimuth of the Sun is the chief ingredient, and how to perform that Geometrically is there taught two ways. But that the like exactness may be in the performance of this also, I shall in this place (before I end) exhibit the manner of finding the Sun's Azimuth at any time, and in any place, by Arithmetical calculation.

Example, In the Latitude of 51 deg. 32 min. the Sun having 17 deg. 56 min. of North declination, and his Altitude 35 deg. Let it be required to find his Azimuth.

First, Add the Complement of the Latitude, the Complement of the Declination, and the Complement of the Suns Altitude all into one sum, and take the half thereof, from which half sum Subtract the Complement of the Declination, and note the difference, as here is done.

Latitude

Arithmetical Dialling.

	deg.	min.		deg.	min.
Latitude	51	32	Complement	38	28
Declination	17	56		72	04
Altitude	35	00		55	00
			summ	165	32
			half summ	82	46

The difference between the half summ and
the Compl. of the Declination $\begin{matrix} 2 \\ 10 \end{matrix}$ 42

Then will the proportion be

(1.) As the Radius 90 deg. 10.00000

Is to the Co-sine of the Altitude 55 deg. 9.91336

So is the Co-sine of the Latitude 38 d. 28 m. 9.79383

To the Sine of 30 deg. 38 min. 19.70719

(2.) As the Sine of 30 deg. 38 min. 9.70719

Is to the Sine of the half summ 82 d. 46 m. 9.99653

So is the Sine of the difference 10 d. 42 m. 9.26873

19.26526

To this Sine 9.55807

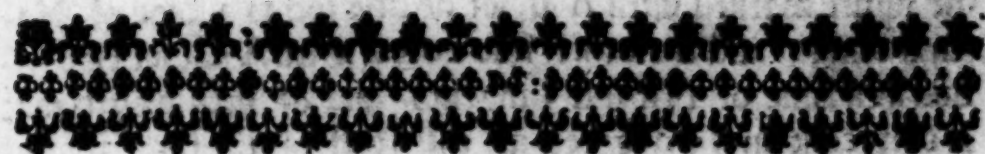
To which add the Radius or Sine of 90 d. 10.00000

The summ is 19.55807

The half summ 9.77903

Which is the Sine of 36 deg. 58 min. the Complement whereof is 53 deg. 2 min. and that doubled is 106 deg. 4 min. which is the Suns Azimuth from the North part of the Meridian, which if you take from 180 deg. there will remain 73 deg. 56 min. which is the Azimuth from the South. And thus may you find the Sun's Azimuth most exactly at any time.

FINIS.



The *ART* of
DIALLING,
INSTRUMENTALLY

Performed :

By a Plain, Cheap, and Portable Instrument,
 accommodated with Lines necessary for that
 purpose. *See opposite Page 1*

PART: III.

C H A P. I.

A Description of the Instrument.

THE Instrument may most conveniently be made of
 Brass upon a thin Plate, (the thinner the better.)
 Let it be made in the form of a right-angled Tri-
 angle, one of the sides containing the right-angle being in
 the

the figure marked with A B, let be divided as a Line of 'Natural Sines, and the other side noted with A C, let be divided as a Line of Natural Tangents, and of such length that it may contain 75 degrees at the least of the same Radius with the Line of Sines. Let both the Sines and Tangents be numbered from A by 10, 20, 30, &c. according to the usual manner, the Sines to 90 deg. and the Tangents to 75 or upwards. — The divisions of both these lines must be graduated close to the outer edges of the Brass as Protractors are usually divided, and the Metal not exceeding that thickness. — On the third Edge B C, is graduated a line of double Tangents of any Radius, such as the Line is capable to receive 45 deg. on either side from the middle thereof, from D to E 45 deg. and from D to F as many; which Tangents are to be numbred not into degrees of a Circle, but into degrees of Time, allowing 15 deg. to 1 hour, 30 for 2 hours, and 45 for 3 hours, and the other intermediate parts for halves and quarters, and in larger Instruments into smaller parts. — This I call the Scale of hours, and must be numbered as in the figure XII. standing at one end, and VI. at the other end thereof, IX. and III. in the middle, and the rest in order, as in the figure. — And it were not amiss, if the Tangent-line A C were marked at the degrees of Time, as well as into degrees of the Circle, which will be useful in the description of East, West, and Equinoctial Dials, both Direct and Declining.

In some convenient place of the Plate you may have one, two, or three lines of Chords, to several Radius's, which will perform the work of the first part of this Book, and will also be serviceable in this.

Also it would be necessary that the other side of the Plate were Graduated for the lines of Sines and Tangents, in all respects, as the fore-side: But for the line of hours it were not

or amiss to have two or three of them of several lengths as in practice you may find occasion for, though one will do all. And this may easily and commodiously be done if the middle of the Plate be cut out, and then on all the inner edges of the Plate you may have several Lines of Hours, and between them Chords also. A Quadrant also maybe projected upon this Instrument, and then it will be serviceable to take a declination of a Plain; for by it you may find the Azimuth. The Instrument thus fitted will be very portable, and very exact and easie in practice. For these last mentioned parts I leave them to Discretion of the Artificer, or the Will of the Owner, the first three lines being sufficient to perform all the following works. This Instrument thus made, I call (in respect of the figure of it) an *Horological Trigon*. The uses whereof are exhibited in the following Chapters.

C H A P. II.

How to draw the Hour-lines upon all sorts of Direct Plains, by help of the Horological Trigon.

D*ials* may be delineated upon all sorts of Plain Superficies, by help of this *TRIGONAL INSTRUMENT*. And that I may retain herein, the like method as I have observed in the two foregoing *Treatises*, I shall begin with the *Direct Plains* first, and from them proceed to the *Oblique*. And in my prosecution hereof, I shall more lightly pass over such things, as I have in the first Part more particularly handled, so by this means the Subsequent Treatise will be the more brief, and the less cumbered with Precepts: And I shall begin with such Plains as are *Direct*, whether *Erect* or *Reclining*.

SECT.

S E C T. I.

How to draw the Hour-lines upon a Vertical, or Horizontal Plain, as also upon any direct North or South Plain in any Latitude, whether Erect or Reclining.

THere is no difference in the construction of these several sorts of Dials, the height of the Pole or Stile above the plain being first attained, which how to effect, is at large taught Geometrically in the first Part Chap 3. and in the second Part Sect. 1. and therefore in this place will be needless to recite. Wherefore let us take one Example for all-viz.

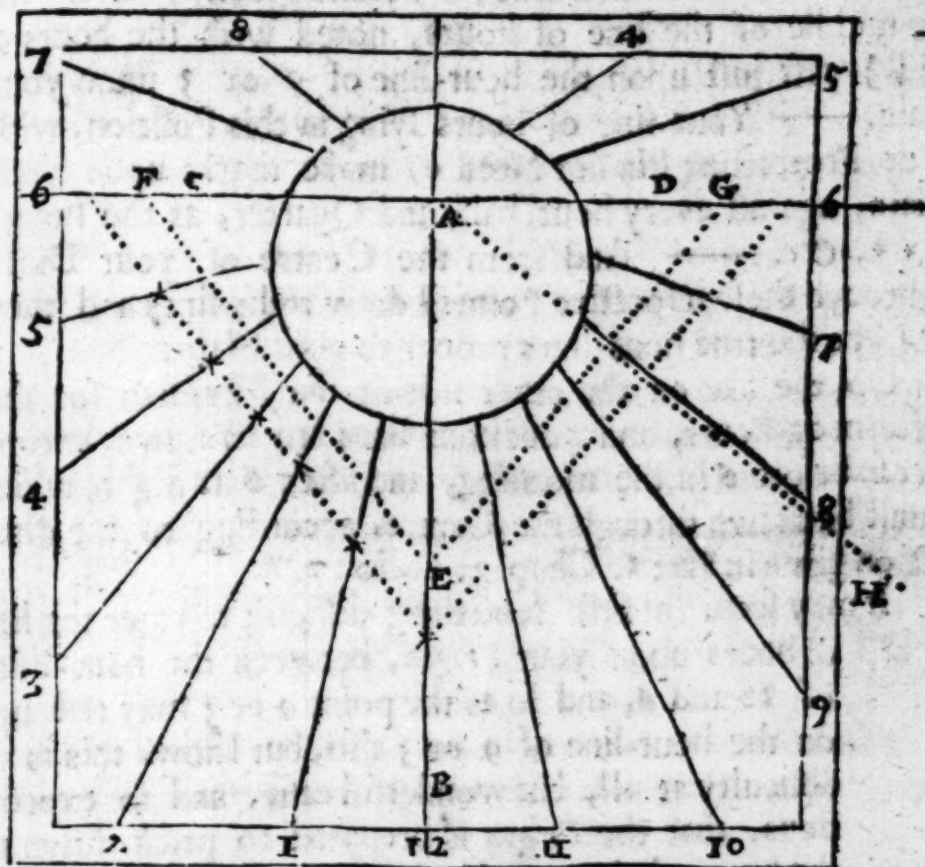
To draw the hour-lines on a Vertical or Horizontal Plain, in the Latitude of 51 deg. 32 min.

First, Upon your Plain (or upon a Sheet of Paper) draw a right-line A B for the Meridian (or hour-line of 12,) and assigning any point therein (as A) for the Centre of your Dial, and through it draw the line C A D at right-angles, for the hour-line of 6.

Secondly, Lay the Centre of your Trigon, to the Centre of your Dial, so that the Tangent-line thereof may lye upon the line of 12, and the line of Sines upon the line of six.

Thirdly, With a Needle (or Protracting Pin) make a Marke upon the Meridian-line, against (the Radius or) 45 deg. as the point E. And upon the line of 6 make another marke, against the Sine of your Stiles height (in this Example against 51 deg. 32 min.) as at F, and draw the line E F. Do the like on the other side of the Meridian-line, by making

H Dial



ing $A G$ equal to $A F$, and draw the line $E G$.

Fourthly, Divide the lines $E F$ and $E G$ (each of them) into two equal parts, in the points 9 and 3 , and from the Centre of your Dial through these points 9 and 3 , draw two right-lines, which shall be the hour-lines of 9 and 3 of the Clock.

Fifthly, For the drawing of the rest of the hours, Lay the line of hours upon your Trigon to your Plⁿ, in such manner, that the Point or end thereof noted with 6 , and the other end or point thereof noted with 12 , may justly touch the hour-lines of 12 and 6 upon your Dial plain, and move the line of hours between the two hour-lines of 12 and 6

and 6 backwards or forwards (as occasion shall require) till the middle of the line of hours, noted with the hours 9 and 3, rest just upon the hour-line of 9 or 3 upon your Plain. — Your line of hours lying in this Position, with your Protracting Pin (or Needle) make marks upon your Plain, against every hour, half, and Quarter, as the Points * * *, &c. — And from the Centre of your Dial, (through these respective Points) draw right lines and they shall be the true hour-lines proper to your Plain.

Do the like on the other side of the Meridian for the afternoon-hours, and your hour-lines are all drawn, except those before 6 in the morning, and after 6 at night, which must be drawn through the Centre, according to the direction given in Part 1. Chap. 3. Folio 37.

It may seem (at first) something difficult to enter the line of hours upon your *Trigon*, between the hour-lines of 12 and 6, and so as the point 9 or 3 may rest upon the hour-line of 9 or 3 also, but know, this is no difficulty at all, but wonderful easie, and so expeditious, that the *Trigon* is prepared to prick down all the hours, halves, and quarters, as soon as you could with your Compasses take one of them out of a Scale, and will give you the hour-points upon the Plain more exact than you can set them well off with the Compasses. — And farther Note, that your *Trigon* lying in this Position, the line of hours on your *Trigon*, will always lye Parallel to the line s E F, and E G, if there be no former error.

Lastly, For the height of the Stile above the Plain (it is in this example equal to the Latitude of the place 51 deg. 31 min.) this you may set off by a line of Chords (as hath been often shewed before) but by the *Trigon* thus. — Lay the Centre of your *Trigon* upon the point E, the line of Sines

Sines lying upon the Meridian (or 12 a clock) line, then against the Tangent of 51 deg. 32 min. make a marke as H, and draw the line A H for the Stile, so is your Dial finished.

And according to this precept may the hour lines upon all North and South Direct Plains be drawn, without any farther trouble, and so for such Plains let this one precept suffice.

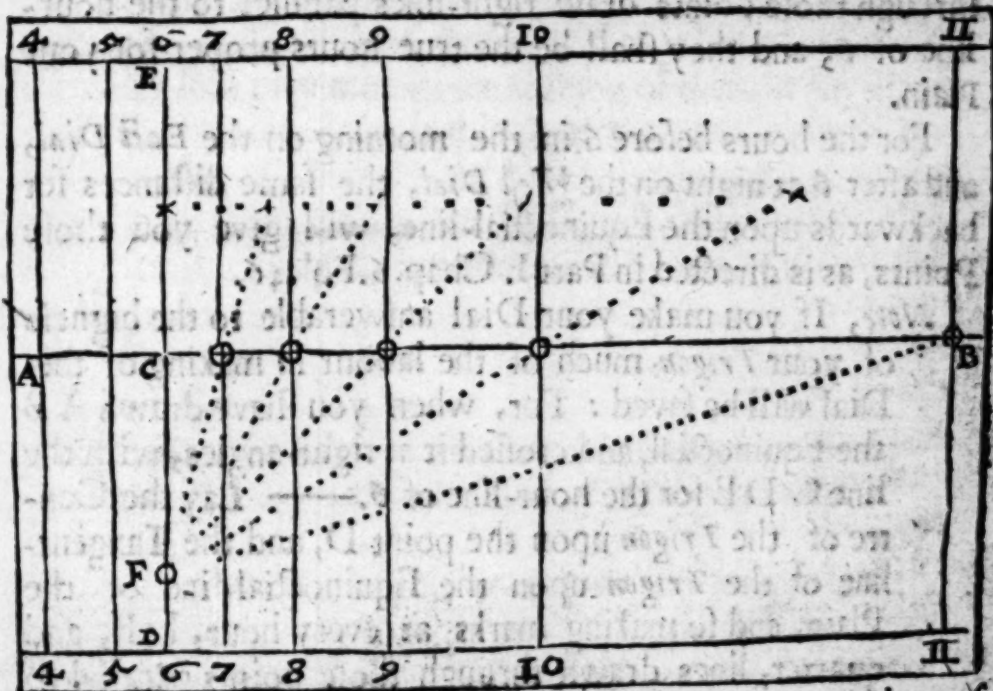
N & S
V dia

S E C T. II.

How to draw the hour-lines upon the Direct East West upright, and Equinoctial Reclining Plains, by help of the Trigon.

Our Example shall be of an East Erect Direct Plain in the Latitude of 51 deg. 32 min. Wherefore

First, Draw (by the directions in Part I. Chap. 6. Folio 44.) a right-line A B, for the Equinoctial, and in any point



X

thereof,

thereof, as at C draw a right-line D C E (at right-angles thereunto) for the hour-line of 6.

Secondly, Assign any point in the hour-line of 6, (proportional to the bigness of your Plain) as F for the height of your perpendicular Stile, or Gnomon.

Thirdly, Lay the Trigon to your Plain, so that the Line of Sines may lye just upon the hour-line of 6, and the end thereof at 90 deg. upon the point F. — The *Trigon* lying in this Position, with your Needle or protracting Pin, make marks upon your Plain, by the side of the Tangent-line upon your *Trigon*, at every hour, half, and quarter at the marks * * * *, &c. (for the Tangent-line upon the *Trigon* is divided into hours and parts of time, as well as into degrees and minutes.)

Fourthly, Lay a Ruler to F, and every one of these hours, halves, and quarters, and where the Ruler crosseth the Equinoctial-line of the Plain A B, as at the points O O O, &c. through those points draw right-lines parallel to the hour-line of 6, and they shall be the true hours proper for your Plain.

For the hours before 6 in the morning on the *East Dial*, and after 6 at night on the *West Dial*, the same distances set backwards upon the Equinoctial-line, will give you those Points, as is directed in Part I. Chap. 6. Fol. 46.

Note, If you make your Dial answerable to the bigness of your *Trigon*, much of the labour in making of this Dial will be saved: For, when you have drawn A B the Equinoctial, and crossed it at right-angles, with the line C D E for the hour-line of 6. — Lay the Centre of the *Trigon* upon the point D, and the Tangent-line of the *Trigon* upon the Equinoctial-line of the Plain, and so making marks at every hour, half, and quarter, lines drawn through those points parallel to the

the hour-line of 6, shall be the true hours proper for the Plain. — And here *Note* also, that the line A B first drawn, must make an angle with the Horizontal plain, equal to the Complement of the Latitude of the place, for which the Dial is made.

What is said of the East Plain, the same is to be understood of the West, as in Part I. Chap. 6. Fol. 46. and the same of the Equinoctial Plain also, only the 6 a clock hour-line in these Plains, is the 12 a clock hour-line in those, as in Part I. Chap. 12. is sufficiently explained.

C H A P. III.

How to draw hour-lines upon any Erect Plain, Declining East or West, by help of the Horological Trigon:

THese are the Dials, which (of all others) are most in use, and therefore will require the more care in the practice of the making of them; and that I may remove all difficulties that may arise in the making of them at any time, I shall be the more large in this particular, for (indeed) upon the making of these Dials in all Latitudes, doth depend the making of all other Oblique Dials, whether Reclining or Inclining, as hereafter shall be taught: And first take an

S E C T. I.

Example of an Erect or Upright Plain, declining from the South Eastward 30 deg. in the Latitude of 51 deg. 30 min.

First, Draw a perpendicular or down-right-line A 12 B, for the Meridian and hour-line of 12, and making choice of some convenient point therein, as A for the Centre of

X 2

your

laying the Centre of the *Trigon* upon E, and the line of Sines upon the perpendicular, make a mark against the Co-fine of the Plains declination 60 deg. as at F, and draw the line A F for the Stile.

Fifthly, Laying the Centre of the *Trigon* to B, and the line of Sines upon A B, make a mark against the Co-tangent of the latitude of the place 38 deg. 28 min. as at D, and through the point D draw the line D C parallel to A B.

Sixthly, Take in your Compasses the distance B E, and set it upon the line C D from C to G, and draw the line C G for the hour-line of 6, quite through the Centre, as the line 6 A 6.

Seventhly, Through the point H, draw the line H R, parallel to A B, cutting the hour-line of 6 in the point 6, and make A 6 above the Centre, equal to A 6 below the Centre, and the line A 12, equal to E F, drawing the lines 12. 6. and 12. 6. which divide into two equal parts in the points 9 and 3, and draw the lines A 9, and A 3, for the hour-lines of nine and three.

Eighthly, Apply the line of hours upon your *Trigon*, between the hour-lines of 6 and 12, so that 9 and 3 may rest upon 9 and 3 as hath been before prescribed, and make marks at the several hours, as the points *, **, &c. through which points, and the Centre A, draw the hours, and so the halves, and quarters, if you please.

For the line of 5 in the morning, it is drawn by extending the hour-line of 5 at night through the Centre, and in the making of this Dial you have made four Dials, as is declared, and largely insisted upon, Part I. Chap. 8. Pag. 53. and therefore no more need be said of it in this place.

These Precepts bere delivered, are sufficient for the making of Upright Declining Dials in any latitude, but most conveniently in these middle latitudes, under the temperate:

temperate Zones, in the Torrid and Frigid Zones there may fall out some inconveniencies, for when the latitude is either very great or very small, such as the lines on the *Trigon* are not capable to receive, there are other means to remedy those inconveniencies, which shall be cleared by the two following Propositions, one whereof shall shew how to effect the work of this Chapter, when the latitude is very small, the other when it is very great.

S E C T. II.

P R O P. I.

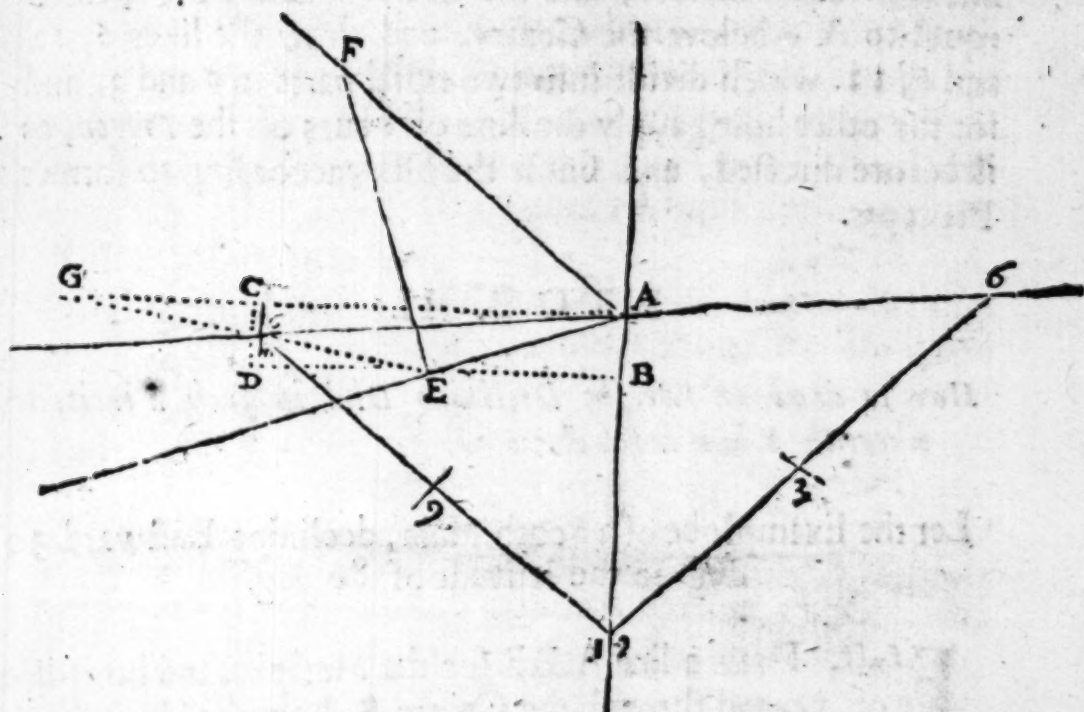
To draw an Upright Declining Dial in such a latitude, where the Pole hath but small elevation.

Let the Example be of an Upright South Plain Declining Eastward 30 deg. in the Latitude of 10 deg.

First, Draw a line A B 12 for the Meridian and hour-line of 12, and make choice of a point therein for a Centre as A, through which draw a line perpendicular thereto for the Horizontal-line of the Plain, as the line G C A.

Secondly, Lay the Centre of the *Trigon* to the Centre of the Dial, and the Tangent-line thereof upon the line A B 12. And against 90 deg. or the Radins of the line of Sines, make a mark as C, and also against 80 deg. thereof, which is the Complement of the latitude of the place, as at H. Likewise against the Tangent of the latitude 10 deg. make a mark as at B, and draw the lines B D parallel to the Horizontal-line G C A, and the line C D parallel to the Meridian-line A B.

Thirdly,



Thirdly, Lay the Centre of the *Trigon* upon B, and the line of Sines upon B D, and make a mark against the Sine of the Plains declination 30 deg. as E, and draw the line A E for the Substilar-line of the Dial; then take the distance B E, and set it upon the Horizontal-line of the Plain from C to G, and draw the line E G, cutting the line C D in K, so shall A K be the hour-line of 6.

Fourthly, Upon the point E, erect the perpendicular E F, and laying the Centre of the *Trigon* upon E, and the line of Sines upon E F, make a mark against the Sine of the Complement of the Plains declination 60 deg. at the point F, and draw the line A F for the Scale.

Fifthly, Through the point H, draw the line H M, parallel to the line A B, cutting the hour-line of 6 in the point 6. then taking the distance E F in your **Compasses**, make the line

line A 12 equal thereto, and the line A 6 above the Centre equal to A 6 below the Centre, and draw the lines 6, 12 and 6, 12. which divide into two equal parts in 9 and 3, and for the other hours apply the line of hours of the *Trigon*, as is before directed, and finish the Dial, according to former Precepts.

P R O P. II.

How to draw an Upright Declining Dial in such a latitude where the Pole is much elevated.

Let the Example be of a South Plain, declining Eastward 30 deg. in the latitude of 80 deg.

F*irst*, Draw a line A B R for the Meridian and hour-line of 12, and through the Centre A draw the Horizontal-line C A perpendicular thereunto.

Secondly, Lay the Centre of the *Trigon* to the Centre of the Dial, so that the line of Sines may be upon the line A B, and the line of Tangents upon A C, then against the Radius or Sine of 90 deg. make the marke B, and against the Co-sine of the Plains declination 30 deg. make the marke 12; also, against the Co-tangent of the latitude make the marke or point C, and draw the line C D parallel to A B, and the line B D parallel to C A.

Thirdly, Lay the Centre of the *Trigon* to C, and the line of Sines upon C B, and against the Sine of the Plains declination 30 deg. make the point G, and make B R equal to C G, then draw the line R G, cutting the line B D in E, so shall A E being drawn be the Substile, and A G the hour-line of 6.

Fourthly, Take in your Compasses the distance A 12, and
set

C H A P. IV.

The Declination and Reclination of a Plain, in a known Latitude being given, to find in what Latitude the said Reclining Declining Plain, shall be an Upright Plain, and also what Declination the same shall have in that new Latitude, and how much the Meridian ascends above, or descends below the Horizontal-line of the Plain, and which ways.

SUPPOSE a Plain in the Latitude of London 51 deg. 32 mi. should decline Northerly 90 deg. and Recline also 54 deg. (such a Plain is the last Example of North Reclining Declining Plains, in the first Part of this Book.) And it were required to find.

1. In what Latitude that would be an Upright Plain.
And
2. What Declination it shall have in that new Latitude.
And
3. How much the Meridian is elevated or depressed above or below the Horizontal-line.

S E C T. I.

To find the new Latitude.

First, Draw a Right-line B A, and at the end thereof A, raise a perpendicular A C.

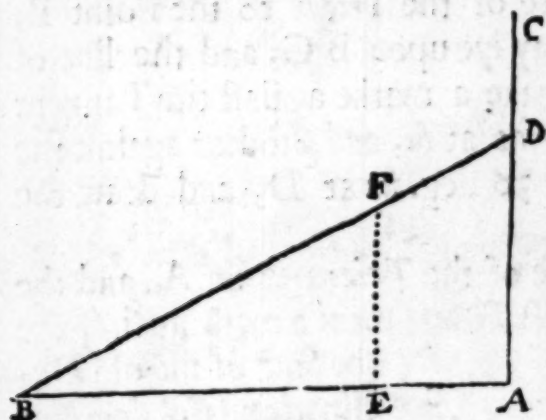
Secondly, Lay the Centre of the Trigon to the point A, so that the line of Sines may lye upon the line A C, and the line of Tangents upon A B, Then

Thirdly, Make a mark against the Co-sine of the Plains declination 30 deg. as D, and another mark against the Radius,

dius or Tangent, of 45 deg. as at B. — Then turning the Centre of the *Trigon* to B, lay the Tangent-line upon B A, and make a mark against the Co-tangent of the Plains Reclination 36 deg. as at E.

Fourthly, Draw the line D B, and apply the Centre of the *Trigon* to E, so that the line of sines may lye upon E A: Then will the line D B lye under the Tangent of 19

deg. 58 min. This Tangent of 19 deg. 58 min. you must compare with the Complement of your old latitude 38 deg. 28 m. in North Reclining Plains (as in this Example) and take their difference, which is 18 deg. 30 min. And



that is the new Latitude.

And here *Note*, that if the Tangent E F before found prove to be equal to the Complement of your old Latitude, then will your Plain be a Polar Declining Plain.

But again,

In South Reclining Plains, you must compare the Tangent E F with your Latitude, and find their difference, the Complement of which difference shall be your new Latitude.

And *Note* farther. That (in South Recliners,) If the Tangent E F be less than your old Latitude, the contrary Pole is elevated; and if it be equal to your old latitude, then it is an Equinoctial Plain.

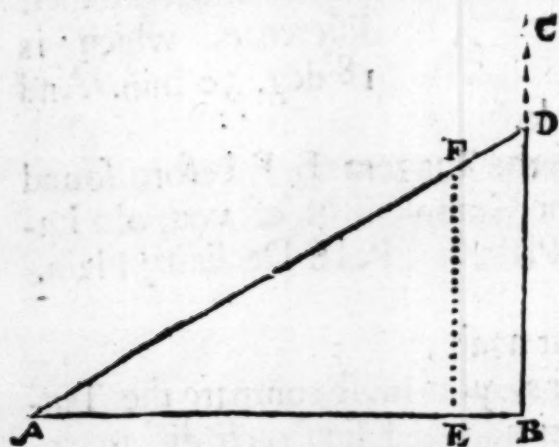
S E C T. II.

To find the new Declinations.

First, Draw a right-line A B, and upon the point B erect the perpendicular B C.

Secondly, Lay the Centre of the *Trigon* to the Point B, so that the line of Sines may lye upon B C, and the line of Tangents upon A B, then make a mark against the Tangent of 45 deg. (or the Radius) as at A, and another against the Co-sine of the Reclination 36 deg. as at D, and draw the line A D.

Thirdly, Lay the Centre of the *Trigon* upon A, and the line of Sines upon the line A B, and make a mark against the Sine of the old Declination (60 deg.) as at E.



Fourthly, Lay the Centre of the *Trigon* to E, and the Tangent-line upon A E, so that the line A D lye just under the Sine of 30 deg. 38 min. in the *Trigon*, at the Point F,

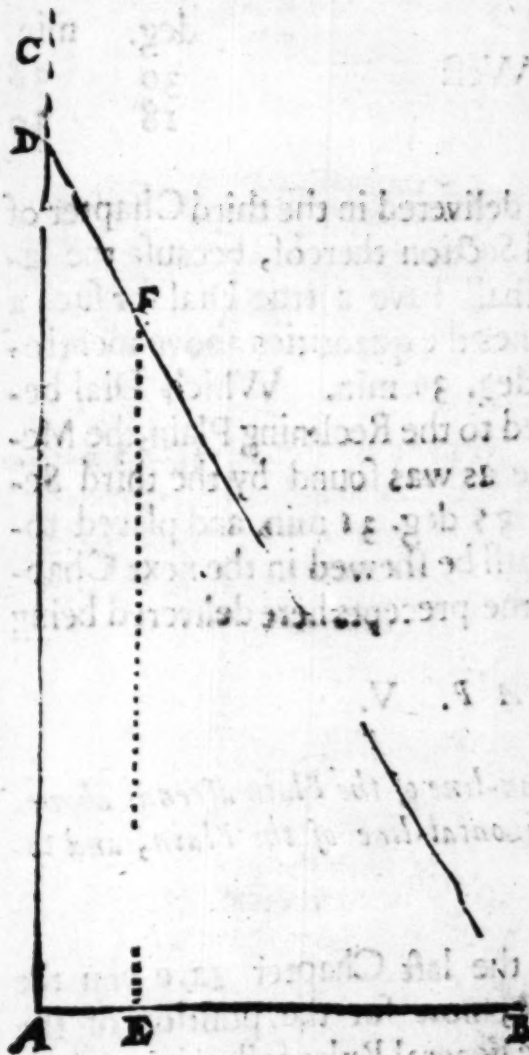
and this 30 deg. 38 min. is the new Declination.

And here note, that this new Declination thus found, is always to the same Coast, Eastward or Westward with the old, but always less in quantity.

S E C T. III.

To find the Angle that the Meridian makes with the Horizontal-line of the Plain.

First, Draw the two lines A B, and A C, making a right-angle at A.



Secondly, Lay the Centre of the Trigon to A, and the Tangent-line upon A C, and make a mark against the Tangent of the old Declination 60 deg. at D, and another against the Sine of 90 deg. and draw the line B D.

Thirdly, Lay the Centre of the Trigon upon B, and the Sines upon the line B A, making a mark against the Sine of the Reclination 54 deg. at E.

Fourthly, Lay the Centre of the Trigon to E, and the Sines upon E B, then will the line B D, lye just under the Tangent of 54 deg.

54 deg. 29 min. which is the Complement of 35 deg. 31 min. and an Angle of that quantity doth the Meridian make with the Horizon.

By these three Sections of this Chapter, you have reduced your North Plain, in the Latitude of 51 deg. 32 min.

Reclining 54 deg. 00 min. And

Declining 60 00.

To an Upright Declining Plain in another latitude, viz.

	deg.	min.
North Plain declining West	30	38
In the Latitude of	18	30

So that if by the Precepts delivered in the third Chapter of this Part and by the second Section thereof, because the latitude is but small, you shall have a true Dial for such a Plain, as declines and Reclines the quantities above mentioned, in the latitude of 51 deg. 32 min. Which Dial being truly drawn, and applyed to the Reclining Plain, the Meridian making such an Angle as was found by the third Section of this Chapter, viz. 35 deg. 31 min. and placed towards the right Coast (as shall be shewed in the next Chapter) your work is finished, the precepts here delivered being general.

C H A P. V.

Shewing whether the Meridian-line of the Plain ascends above, or descends below the Horizontal-line of the Plain, and towards what Coast.

THe third Section of the last Chapter gave you the quantity of this Angle, now for the position of the Meridian-line, observe these general Rules following, viz.

In

North Incliners.
In } South Recliners.

{ Less than Equinoctial, the Meridian must be drawn

{ above } That end of the Horizontal-line, which lies contrary to the Coast of the Plains declination.

{ below }

{ More than Equinoctial, the Meridian must be drawn

{ below } That end of the Horizontal-line, which lies the same way with the Coast of the Plains declination.

{ above }

{ Less than a Polar the Meridian must be drawn

{ above } That end of the Horizontal-line that looks the same way with the Coast of the Plains declination. — And this Meridian thus drawn in North Recliners represents 12 at midnight.

{ below }

North Recliners,
In } South Incliners.

{ Equal to a Polar, the Meridian must be drawn below the Horizontal line at that end which is contrary to the Coast of Declination, and the six of clock hour-line is always the Substile.

{ More than a Polar, the Meridian must be drawn

{ below } And from that end of the Horizontal-line, which lies contrary to the Coast of the Plains declination, — And in South incliners it is only serviceable to help to draw the rest of the Dial.

{ above }

Your Dial being drawn by the Precepts delivered in the third Chapter of this Part, according to its new Latitude, and new Declination, and the situation of the Meridian-line from the Horizontal-line, discovered by this Chapter, you may now proceed to

The Placing of the Dial upon the Plain.

Which to perform, having by the directions given, drawn an Horizontal-line upon your Plain, set off so many degrees (by help of your line of Chords) as the distance of the Meridian from the Horizon is found to be, and to the same Coast, and there draw the Meridian-line. Having so done apply your Paper-draught to your Plain, and lay the Meridian-line thereof upon (or parallel to) the Meridian-line upon your Plain, and herein be careful that the Stile of your Paper-draught (or rather a true patern thereof out in Past-board or Paper) being placed upon the Substilar do directly behold, or point towards the elevated Pole; which consideration being had, you may easily transfer the rest of the hour-lines from your Paper to your Plain, and put no more thereon than are necessary.

C H A P. VI.

How to deal with East and West Reclining and Inclining Plains.

THese also must be referred to a new Latitude, and new declination, which are easily attained; the new Latitude being always the Complement of your own Latitude, and the new Declination in that Latitude is the Complement of their Reclination. These being known, you may describe

scribe the Dial according to the Rules of the third Chapter.

The Meridian-line in all these Dials, is the same with the Horizontal-line, and so hath no elevation or depression.

C H A P. VII.

Of North and South Reclining and Inclining Plains.

When the Reclination or Inclination of any of these Plains is known, there is nothing else required before the drawing of the Dial, but the elevation of the Pole above the Plain, which how to find is plainly taught in the fourth and fifth Sections of the second Part, and then the Dials are made as Vertical or Horizontal Dials for those Latitudes, and so no more need to be said of them in this place. And so I shall conclude this third Part.

CONCLUSION

I shall conclude this third Part with these two general and necessary Rules, teaching

1. To know which way the Substilar-line of any Dial must stand from the Vertical-line of the same Plain.
And
- 2 How to order your work in the Southern Hemisphere.

Instrumental Dialling.*For the First,*

Upon all Plains whereon the
 { North Pole South Pole }

Is elevated, the Subtilar must
 lye from the

{ upper end lower end }

of the Vertical line
 towards the full

{ North South }

For the Second.

All the Rules, Precepts, and Examples given in this Book, do suppose you to be in the Northern Hemisphere of the World, therefore if you should be in the Southern Hemisphere, these Precepts will serve there also, by only changing the words North and South one into the other, as for South read North, and for North read South, and so Northern for Southern, and the contrary.

The End of the third Part



A P P E N D I X.

FOrasmuch as the Latitude of the place, and the Suns place, or declination (rather) are such necessary ingredients in the making of Dials, that you can hardly make a Dial in any part of the World, but you must first know in what Latitude that place is. And also when the Latitude of the Place is known, the Situation of the Plain must also be obtained; which can hardly be done without knowing the Suns Azimuth, (for I wholly reject that way of the Magnetical Needle) and that Azimuth will require the Suns Declination to the finding of it. I thought good at the conclusion of this Book to add a Table of the Suns Declination for every day in the year, which may be ready at hand, when at any time you are to take the Declination of a Plain: And also a Table of the Latitudes of the Principal Cities and Towns in *Great Brittain* and *Ireland*, so that if you are to make a Dial in any of those parts, you may have recourse to this Table, and make your Dial to the Latitude of that place, which you find to be nearest to the place where you are to make your Dial.

A Table of the Suns Declination.

days.	January		Februar.		March		Apr. I		May		June	
	d.	mi.	d.	mi.	d.	mi.	d.	mi.	d.	mi.	d.	mi.
1	21	44	13	46	3	24	8	36 18	5	23	12	
2	21	33	13	26	3	0	8	58 18	20	23	16	
3	21	23	13	5	2	37	9	20 18	35	23	19	
4	21	13	12	45	2	13	9	42 18	50	23	22	
5	21	2	12	25	1	49	10	3 19	4	23	25	
6	20	50	12	4	1	25	10	24 19	18	23	27	
7	20	38	11	43	1	1	10	45 19	31	23	29	
8	20	26	11	21	0	38	11	0 19	44	23	30	
9	20	13	11	0	0	14	11	27 19	57	23	31	
10	20	0	10	38	0	10	11	47 20	10	23	32	
11	19	46	10	16	0	33	12	7 20	22	23	31	
12	19	32	9	54	0	57	12	28 20	34	23	31	
13	19	18	9	32	1	21	12	48 20	45	23	30	
14	19	3	9	10	1	44	13	7 20	56	23	29	
15	18	48	8	48	2	8	13	27 21	7	23	28	
16	18	33	8	25	2	31	13	46 21	17	23	26	
17	18	17	8	3	2	54	14	5 21	27	23	23	
18	18	2	7	40	3	18	14	24 21	37	23	20	
19	17	45	7	17	3	41	14	42 21	46	23	17	
20	17	28	6	54	4	5	15	1 21	55	23	14	
21	17	11	6	31	4	28	15	19 22	4	23	10	
22	16	54	6	8	4	51	15	37 22	12	23	6	
23	16	36	5	45	5	14	15	54 22	20	23	1	
24	16	18	5	21	5	37	16	12 22	27	22	55	
25	16	0	4	58	6	0	16	29 22	34	22	50	
26	5	42	4	34	6	22	16	46 22	41	22	44	
27	5	23	4	11	6	45	17	2 22	47	22	37	
28	15	4	3	47	7	7	17	18 22	53	22	31	
29	14	45			7	30	17	34 22	58	22	23	
30	14	26			7	52	17	50 23	3	22	16	
31	14	6			8	14		23	8			

Instrumental Dialling

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A Table of the Suns Declination.

Days	July	August	Septem.	October	Novem.	Decem.
d. mi.	d. mi.	d. mi.	d. mi.	d. mi.	d. mi.	d. mi.
1	22	8 15	12	4 24	7 15	17 4 23 9
2	22	0 14	54	4 2	7 38	17 56 23 13
3	21	5 14	36	3 38	8 0	18 12 23 17
4	21	4 14	17	3 15	8 22	18 28 23 20
5	21	3 13	58	2 52	8 45	18 43 23 23
6	21	2 13	35	2 29	9 7	18 58 23 26
7	21	1 13	20	2 5	9 29	19 13 23 28
8	21	2 13	1	1 41	9 51	19 27 23 30
9	20	5 12	41	1 19	10 13	19 41 23 31
10	20	4 12	21	0 55	10 35	19 55 23 31
11	20	28 12	1	0 32	10 56	20 8 23 31
12	20	16 11	41	0 8	11 18	20 21 23 31
13	20	4 11	21	0 16	11 39	20 34 23 29
14	19	5 11	0	0 39	12 0	20 46 23 27
15	19	38 10	39	1 3	12 21	20 58 23 25
16	19	25 10	18	1 26	12 41	21 9 23 22
17	19	12 9	57	1 50	13 21	21 20 23 19
18	18	58 9	36	2 13	13 21	21 31 23 16
19	18	43 9	15	2 37	13 42	21 41 23 12
20	18	29 8	53	3 0	14 21	21 50 23 7
21	18	14 8	31	3 2	14 21	22 0 23 2
22	17	59 8	9	3 47	14 41	22 9 23 57
23	17	44 7	47	4 10	15 0	22 17 23 51
24	17	28 7	25	4 33	15 19	22 15 23 44
25	17	12 7	3	4 57	15 37	22 33 23 37
26	16	56 6	41	5 20	15 55	22 40 23 30
27	16	39 6	18	5 43	16 1	22 46 23 22
28	16	22 5	56	6 6	16 3	22 52 23 14
29	6	6 5	33	6 29	16 49	22 58 23 5
30	15	48 5	10	6 52	17 6	23 4 22 56
31	15	30 4	47	7 2		21

*A Table of the Names and Latitudes of the
Principal Cities, Towns, and Islands in
and about Great Brittain and Ireland.*

<i>England.</i>			<i>England.</i>		
	D	M		D	M
Bedford	52	8	Northampton	52	14
Barwick	55	54	Norwich	52	42
Bristol	51	27	Nottingham	53	0
Buckingham	52	0	Oxford	51	46
Cambridge	52	12	Reading	51	28
Canterbury	51	17	Salesbury	51	4
Carlisle	55	0	Shrewsbury	52	47
Chichester	50	48	Stafford	52	32
Chester	53	16	Stamford	52	38
Colchester	51	58	Truero	50	30
Derby	52	58	Warwick	52	20
Dorchester	50	40	Winchester	51	3
Durham	54	50	Worcester	52	14
Excester	50	43	York	53	58
Gilford	51	12			
Glocester	51	53	<i>Wales.</i>		
Hartford	51	49		D	M
Hereford	52	7	Anglesey	23	28
Huntington	52	19	Barmouth	52	50
Ipswich	52	8	Brecknock	52	1
Kendal	54	23	Cardigan	52	12
Lancaster	54	10	Carmarthen	51	56
Leicester	52	40	Carnarvan	53	16
Lincoln	53	14	Denbigh	53	13
London	51	32	Flint	53	17
			Landaffe	51	35
			Monmouth	51	51
					Mont.

Instrumental Dialling.

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<i>Wales.</i>	D	M
Montgomery	51	56
Pembroke	51	46
Radnor	52	19
St. David	52	0

<i>Islands.</i>	D	M
Garnzey	49	30
Jerzey	49	12
Limdy	51	22
Man	54	24
Portland	50	30
Wight	50	39

<i>Scotland.</i>	D	M
Aberdean	57	32
Dunblain	56	21
Dunkel	56	48
Edenburgh	55	56
Glasgow	55	52
Kinfaile	57	44
Orkney	60	6
St. Andrews	56	39
Skyrassin	58	36

<i>Scotland.</i>	D	M
Sterling	56	12

<i>Ireland.</i>	D	M
Antrim	54	38
Arglas	54	10
Armah	54	14
Caterlagh	52	41
Clare	52	34
Corke	51	53
Droghedagh	53	38
Dublin	53	13
Dundalke	53	52
Galloway	53	2
Youhall	51	53
Kenny	52	27
Kildare	53	0
Kingstown	53	8
Knockfergns	54	37
Kynsale	51	41
Lymerick	52	30
Queens Town	52	52
Waterford	52	9
Wexford	52	18

FINIS.

40 0 - 9m Hour Distance from ...
0 - 11 - 17 - 23 - 13 36 - 37 - 52 - 9 - 70 - 11 - 9

$\frac{1}{2}$ 11 - 19 - 23 - 10 36 - 43 52 - 12 70 - 16

$\frac{1}{2}$ 11 - 21 - 23 - 23 36 - 50 52 - 22 70 - 19

$\frac{3}{4}$ 11 - 23 - 23 - 20 36 - 43 52 - 20 70 - 24

49 11 - 25 - 23 - 33 37 - 3 52 - 35 70 - 20 - 90

$\frac{1}{4}$ 11 - 27 - 23 - 37 37 - 9 52 - 55 70 - 29

$\frac{1}{2}$ 11 - 30 - 23 - 42 37 - 16 53 - 16 70 - 30

$\frac{3}{4}$ 11 - 33 - 23 - 47 37 - 24 53 - 0 70 - 36

50 11 - 35 - 23 - 52 37 - 20 53 - 0 70 - 43 - 90

$\frac{1}{4}$ 11 - 30 - 23 57 37 - 29 53 - 6 70 - 44

$\frac{1}{2}$ 11 - 40 - 24 - 1 37 - 30 53 - 12 70 - 46

$\frac{3}{4}$ 11 - 42 - 24 - 5 37 - 41 53 - 10 70 - 55

51 11 - 45 - 24 - 9 37 - 52 53 - 24 70 - 59 - 90

$\frac{1}{4}$ 11 - 47 - 24 - 13 37 - 50 53 - 39 71 - 3

$\frac{1}{2}$ 11 - 50 - 24 - 10 30 - 3 53 - 35 71 - 6

$\frac{3}{4}$ 11 - 52 - 24 - 22 30 - 9 53 - 40 71 - 9

52 11 - 55 - 24 - 27 30 - 13 53 - 46 71 - 12

12 o'clock 010 0

37 ^m 7 1/2

30

4.60 -

Polar Dial

1 = 15 = 00

5

10

15

20

25

30

35

40

45

50

55

60

2.30 -

1/2

5 = 75 = -

6 = 90 = 00

8 = 45 = -

60 00

1706
1774

12 years, in

John Munn came to
Le Gore Work house Feb. 2. 1774
& in the year 1706

1706
1774

& hath been 12 years
in

In the year 1704
John Munn Worked
for Mr. Jno. Jennings at
Uxbridge &

72.40 90 - 00

19

56.19

34

4.26

3.4

60.00

Bought Augth. 29. 1705

113
5
1.
9
1
6
Ino Munn Bricklayer on

Henry Munn junior Snow Hill at Mr. Clark

purched Augth. 29. 1705 This Book Cost 12 = 1

and came to St. Mary bone Work house
Breby, 2. 1774

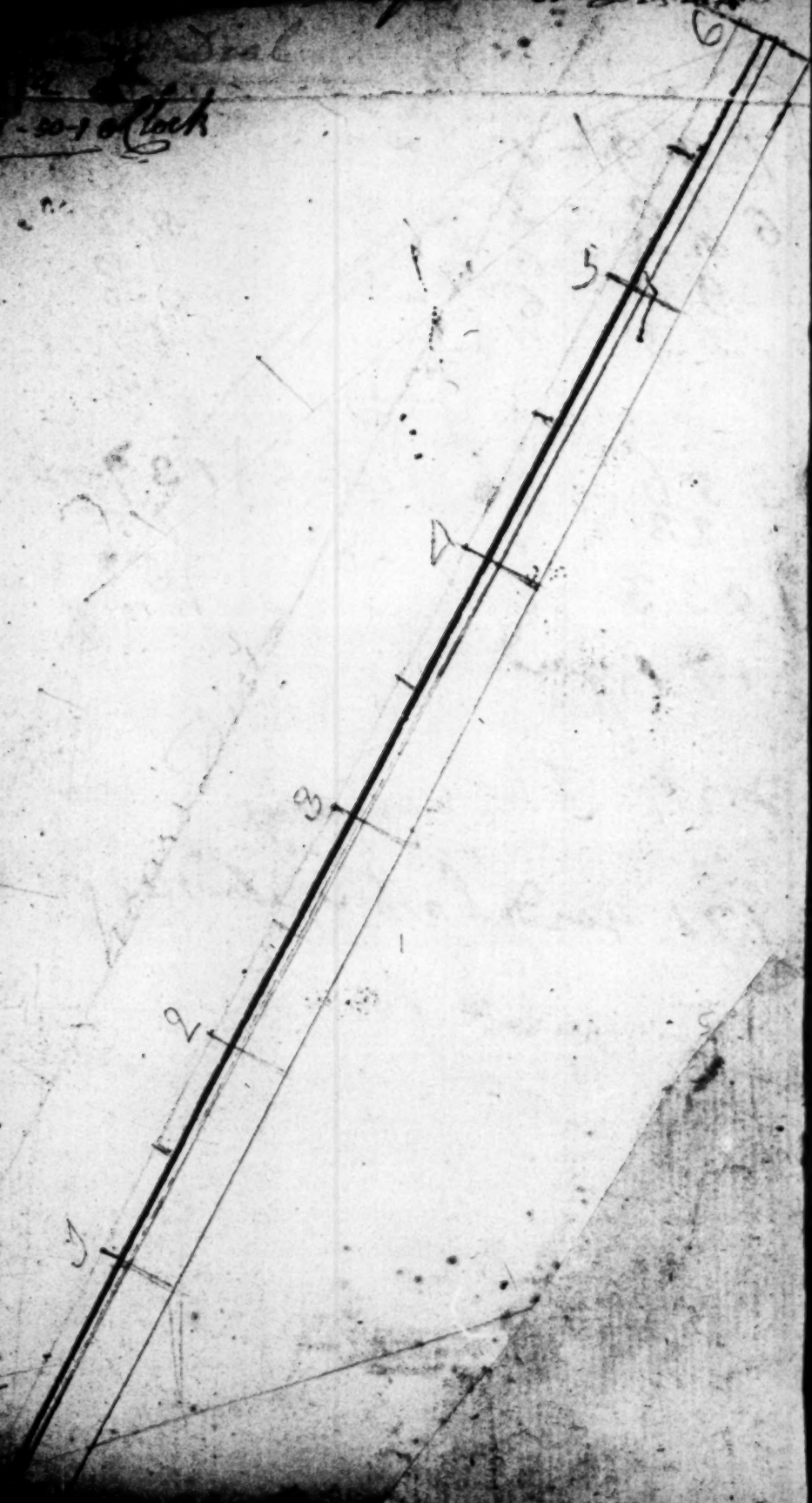
L D. L. 120 200
 749 - 1 23 - 4 75.9 12 - 2
 610 - 3 23.0 24 - 4
 04 - 6 0.3 7 6
 90 - 6 6.9 31 - 0
 13 - 0 14.0
 9.0

556
 23
 1533
 171 yard

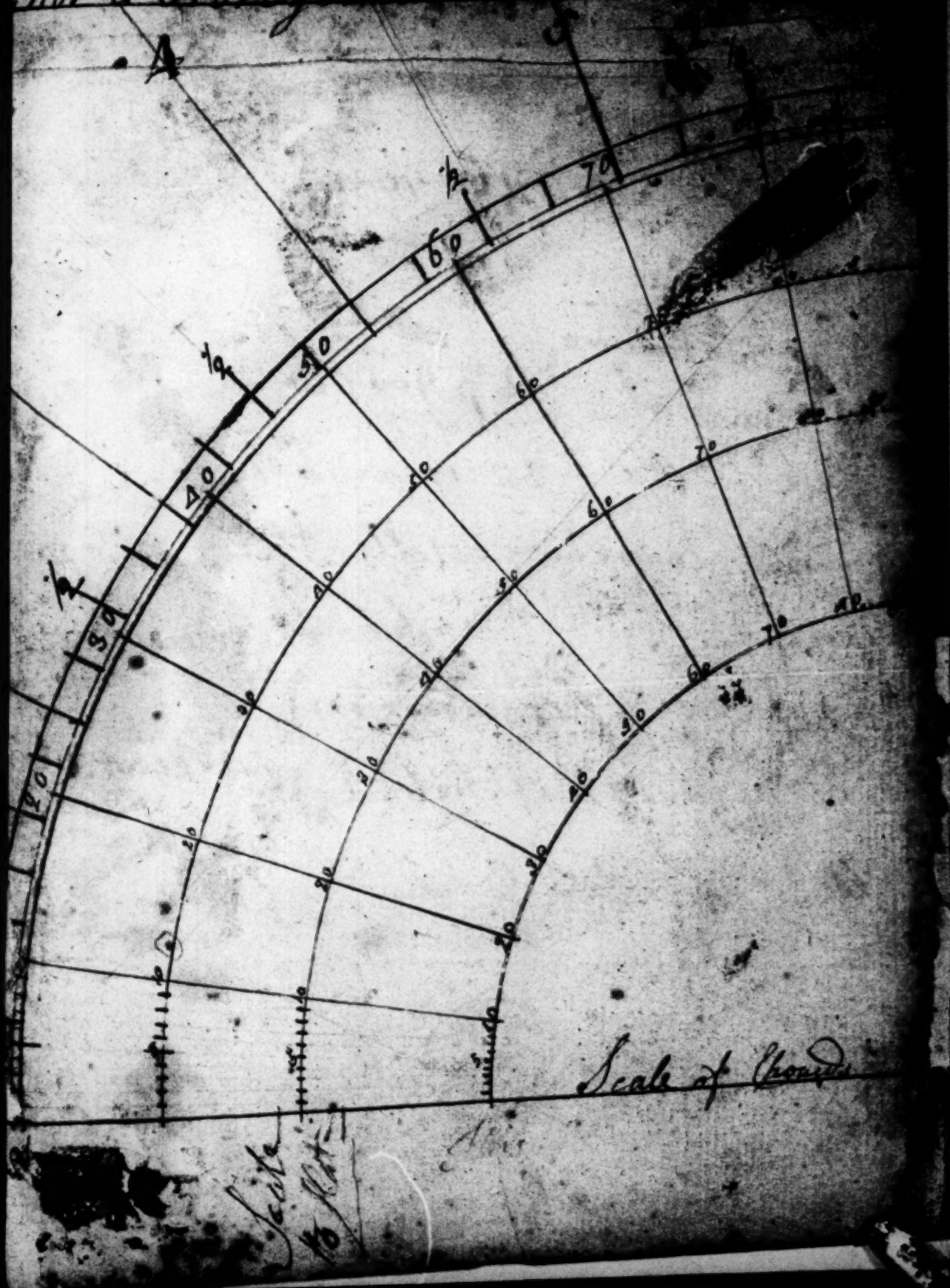
23 - 4 137 - 0 75.0
 75
 16.2 yard

Mr. Thornton, Work by Mr. B.
 171 yards lath & plaster at 0.25 p. yard
 62 yards render — at 0.10 p. yard
 £7.11

11 .. 50
 15 .. 7
 10 .. 5
 21 .. 12
 24 .. 20
 27 .. 45
 31 .. 11
 34 .. 37
 30 .. 3
 41 .. 56
 45 .. 49
 49 .. 42
 53 .. 35
 57 .. 20
 62 .. 21
 66 .. 44
 71 .. 0
 75 .. 51
 80 .. 34
 85 .. 17
 90 .. 00



For a Horizontal



John Munn } 16 years
spent mental }
out of time 29

Came to London
27 years old - 27 years old
married at - 32 years old
lived in Bloomsbury & Wells St
then till came to the workhouse February 2^d
in the year 74th and in
the year 1709 Feb. 2^d ^{have been} 14 years in
the workhouse
the above must be read with care



